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Jurassic Brachiopods of Saudi Arabia

G. ARTHUR COOPER

SMITHSONIAN CONTRIBUTIONS TO PALEOBIOLOGY • NUMBER 63

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Washington, D.C.
1989

ABSTRACT

Cooper, G. Arthur. Jurassic Brachiopods of Saudi Arabia. *Smithsonian Contributions to Paleobiology*, number 65, 213 pages, 48 figures, 37 plates, 1989.—No studies in depth have been made of the brachiopods from the Jurassic deposits of Saudi Arabia. This first study of the brachiopods from this important region is based mainly on a collection presented to the Smithsonian Institution by the Arabian-American Oil Company (Aramco). In addition, the study includes collections made by Drs. P.M. Kier and E.G. Kauffman of the Smithsonian Institution and R.W. Powers, C.D. Redmond and H.A. MacClure of the Arabian-American Oil Company.

Sixty-one genera are described of which 29 are new. Of these 13 rhynchonellid genera are new: *Amydroptychus, Baeorhynchia, Colpotoria, Conarosia, Deltarynchia, Echyrosia, Eurysites, Heteromychus, Lirellarina, Nastosia, Pycnoria, Schizoria,* and *Strongyloria.* Other described genera are: *Burmirhynchia* Buckman, 1917, *Cymatorhynchia* Buckman, 1917, *Daghanirhynchia* Muir-Wood, 1935, *Gibbirhynchia* Buckman, 1917, *Globirhynchia* Buckman, 1917, *Kallirhynchia* Buckman, 1917, *Kutchirhynchia* Buckman, 1917, *Somalirhynchia* Weir, 1925, *Sphenorhynchia* Buckman, 1917, and *Torquirhynchia* Childs, 1969.

Of Spiriferinacea, one genus, *Calyptoria,* is new and two genera are described: *Liospiriferina* Rouselle, 1977, and *Spiriferina* d'Orbigny, 1847. The Terebratulacea are represented by 11 new genera: *Arabatia, Arabicella, Arapsopleurum, Arapsothyris, Dissoria, Ectyphoria, Pionopleurum, Pleuraloma, Stenorina, Tanyothyris,* and *Toxonelasma.* Seventeen described terebratulaceans are *Apatecosia* Cooper, 1983, *Avonothyris*? Buckman, 1917, *Bihenithyris* Muir-Wood, 1935, *Dolichobrochus* Cooper, 1983, *Dorsoplicathyris*? Almeras, 1971, *Glyphisaria?* Cooper, 1983, *Gyrosina?* Cooper, 1983, *Habrobrochus* Cooper, 1983, *Kutchithyris*? Buckman, 1917, *Loboidothyris*? Buckman, 1917, *Orthotoma* Quenstedt, 1869, *Plectothyris?* Buckman, 1917, *Pseudowattonithyris?* Almeras, 1971, *Somalithyris* Muir-Wood, 1935; *Sphaeroidothyris* Buckman, 1917, *Stiphrothyris*? Buckman, 1917, and *Striithyris* Muir-Wood, 1935.

The Zeilleriacea include four new genera: *Apothyris, Mycerosia, Sphriganaria* and *Xenorina.* Described zeilleriids are *Flabellothyris* Eudes-Deslongchamps, 1884, *Rugitela* Muir-Wood, 1936, and *Zeilleria* Bayle, 1878. A total of 166 species are described and 25 lots are identifiable as species.

Pseudoglossothyris? sulcata Muir-Wood, 1935, from Somaliland (Somali Republic) is shown to be a zeilleriid, and the species is herein transferred to *Aulacothyris. Eudesia cardioides* Douvillé, 1916, is herein transferred to the new genus *Sphriganaria.*

The Liassic Marrat Formation abounds in spiriferinids. The Dhruma Formation (Bajocian to Callovian) is rich in rhynchonellids which dwindle in numbers in late Dhruma beds. The overlying Tuwaiq Mountain and Hanifa formations (Callovian to Kimmeridgian) are conspicuous for the large numbers of terebratulaceans which far outnumber the rhynchonellids.

Correlation with Jurassic sequences near and far is difficult because of the high degree of endemism shown by the Saudi Arabian brachiopods. Precise correlation with British and European faunas is not now possible. Relationships with the Jurassic faunas of the Sinai, Israel and East Africa in the Callovian is suggested by the presence of two species in common and generic representation shown by *Daghanirhynchia, Somalirhynchia, Bihenithyris, Somalithyris,* and *Striithyris.*

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year.* SERIES COVER DESIGN: The trilobite *Phacops rana* Green.

Library of Congress Cataloging-in-Publication Data
Cooper, G. Arthur (Gustav Arthur), 1902–
Jurassic brachiopods of Saudi Arabia.
(Smithsonian contributions to paleobiology ; no. 65)
Bibliography: p.
Supt. of Docs. no.: SI 1.30:65
1. Brachiopoda, Fossil. 2. Paleontology—Jurassic. 3. Paleontology—Saudi Arabia. I. Title. II. Series.
QE701.S56 no.65 560 s [564'.8] 88-600170 [QE796]

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Jurassic Brachiopods of Saudi Arabia

G. Arthur Cooper

Introduction

THE COLLECTION.—The brachiopods on which this monograph is based were collected by field geologists of the Arabian-American Oil Company (Aramco) and by P.M. Kier and E.G. Kauffman of the Smithsonian Institution, accompanied by members of the oil company. The Aramco collections were assembled during routine mapping operations over a period of twenty years, 1933–1953. The combined collections exceed 3300 specimens. Most of the specimens are free of matrix, thus requiring little preparation. The numbers of specimens in each lot suggest the relative abundance of species at that locality. Unfortunately some specimens are so distorted as to be useless for identification. Many lots are lacking in numbers which limits an understanding of their variation and inhibits serial sectioning. Some of the specimens cannot be assigned to specific parts of the column, but most have been referred to the various ammonite zones established by Arkell (1952) and Imlay (1970).

The Kier-Kauffman collections were made in 1962 and were taken from measured sections from the Liassic (Marrat Formation) through the column into the Hanifa Formation omitting the Tuwaiq Mountain Formation. This collection includes a wealth of accurately located specimens. The data furnished by Aramco give detailed localities, the sequence studied and usually a generalized description of the rock types. Usually several rock types are recorded but there is no way from the data given to place the specimens collected in a given rock type. Consequently, it is not possible to correlate these specimens with rock types and determine the paleoecological conditions under which they existed in Jurassic time.

PREVIOUS WORK.—The earliest knowledge of Jurassic rocks in Saudi Arabia was obtained by F.R. Mollet (1871) who collected fossils north of Majhafa, north of Aden. His fossils were determined by Stoliczka (Mollet, 1971) as resembling Upper Jurassic forms. Newton and Crick (1908) next described Jurassic fossils collected by Major H.S. Hazelgrove from north of Aden. The first Jurassic fossils to be described from central Arabia were those collected by H. St. J.B. Philby who made a camel traverse across the peninsula. His fossils were described by R.B. Newton (1921, 1923). Three brachiopods were reported: *Rhynchonella* sp., *R.* of *subvariabilis* Davidson, and *Terebratula subsella* Leymerie. Stefanini (1925), in describing fossils collected by O.H. Little from the Sultanate of Shehr and Makalla in southern Arabia, placed Newton's *Rhynchonella* sp. in synonymy with his *Rhynchonella hadramautensis*, which suggests relationship to *Daghanirhynchia*. The *Terebratula subsella* of Newton suggests a possible species of *Bihenithyris* or *Habrobrochus*. *Terebratula subsella* (auct.) is a widely misidentified Jurassic species, because its generalized form (like that of many other brachiopod species and genera) is defined on external rather than internal characters.

Although few brachiopods have been described from Saudi Arabia, several other fossil groups have contributed to dating the various formations proposed by the Aramco geologists. Most important is the work on ammonites by Arkell (1952), Imlay (1970), and Lewy (1983). The echinoids were described by Kier (1972) who, with Imlay, detected a possible stratigraphic break near the middle of the Atash Member of the Dhruma Formation. Foraminifera have been described by Redmond (1964, 1965).

ACKNOWLEDGMENTS.—I am grateful to Dr. Ellis F. Owen, expert in Mesozoic Brachiopoda, formerly of the British Museum (Natural History), for reviewing with me the genera of Saudia Arabian brachiopods of this study and making valuable suggestions as to their relationships and correlation. He also made available for study Jurassic brachiopods from southern Saudi Arabia, from the Hadhramaut, and also from East Africa.

Dr. J.T. Dutro, Jr., United States Geological Survey, reviewed the manuscript and offered many suggestions for its

G. Arthur Cooper, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

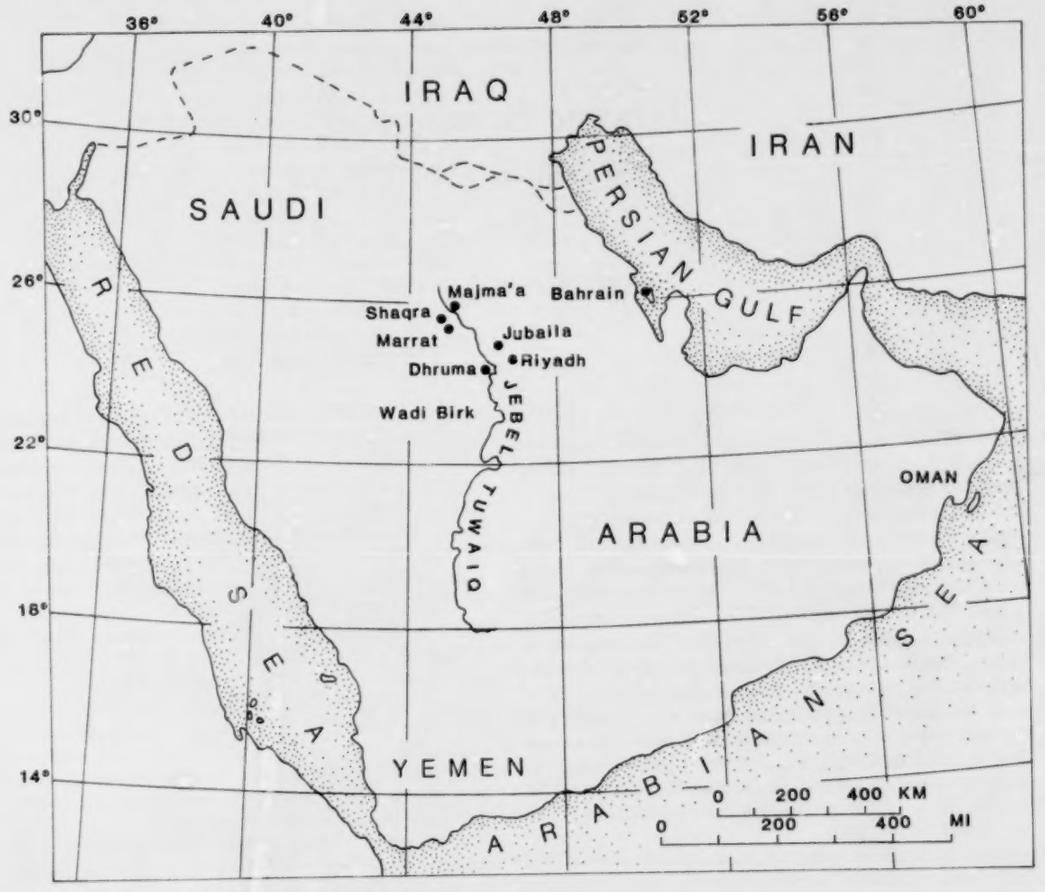


FIGURE 1.—Sketch map of Arabia and Jebel Tuwaiq showing extent of Jurassic exposures and location of some important places.

improvement; I thank him for his helpful advice.

Dr. A.J. Rowell, University of Kansas, loaned specimens of one genus from the Nazer Collection of rhynchonellids from Saudi Arabia.

Mr. Donald A. Dean, Senior Museum Specialist, National Museum of Natural History, devised a grinding apparatus that greatly reduced the time of performing the usually tedious process of making serial sections and acetate peels. To him I give thanks for his help and ingenuity.

My thanks to Dr. Sydney D. Bowers of Arabian-American Oil Company, for making it possible for the Smithsonian's National Museum of Natural History to have this important collection.

The manuscript was typed by Betty Lomax and Diane Cloyd of the Smithsonian Institution. My thanks to them.

The Jurassic System in Saudi Arabia

FORMATIONS

Jurassic strata crop out in an arc across central Arabia, concave to the west and with a maximum eastward bulge west of Riyadh (Figure 1). The Jurassic is 1126 m (3693 ft) thick, rests unconformably on Triassic strata (Minjur Formation), and is overlain by the Cretaceous. The Jurassic consists of seven formations in ascending order: Marrat, Dhruma, Tuwaiq

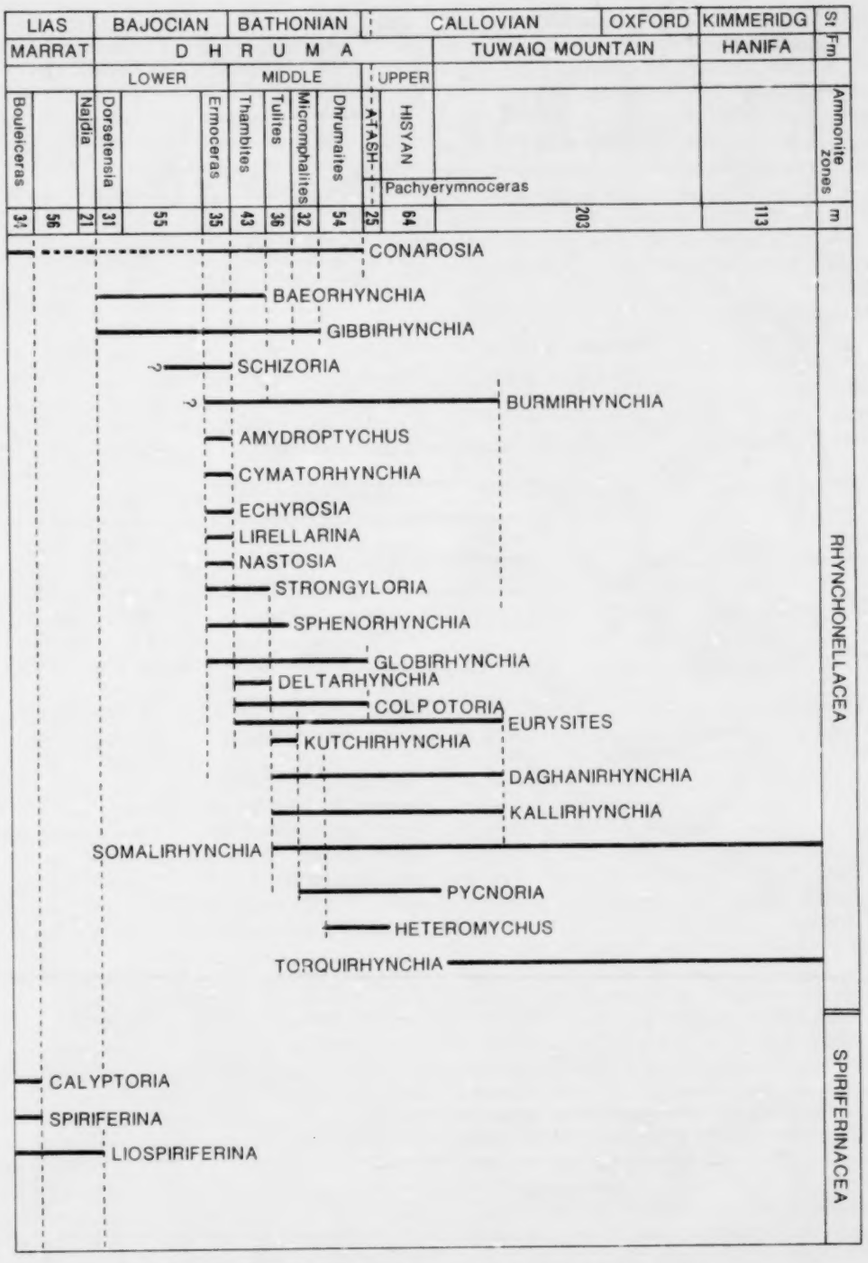


FIGURE 2.—Geological distribution of genera of Rhynchonellacea and Spiriferinacea.

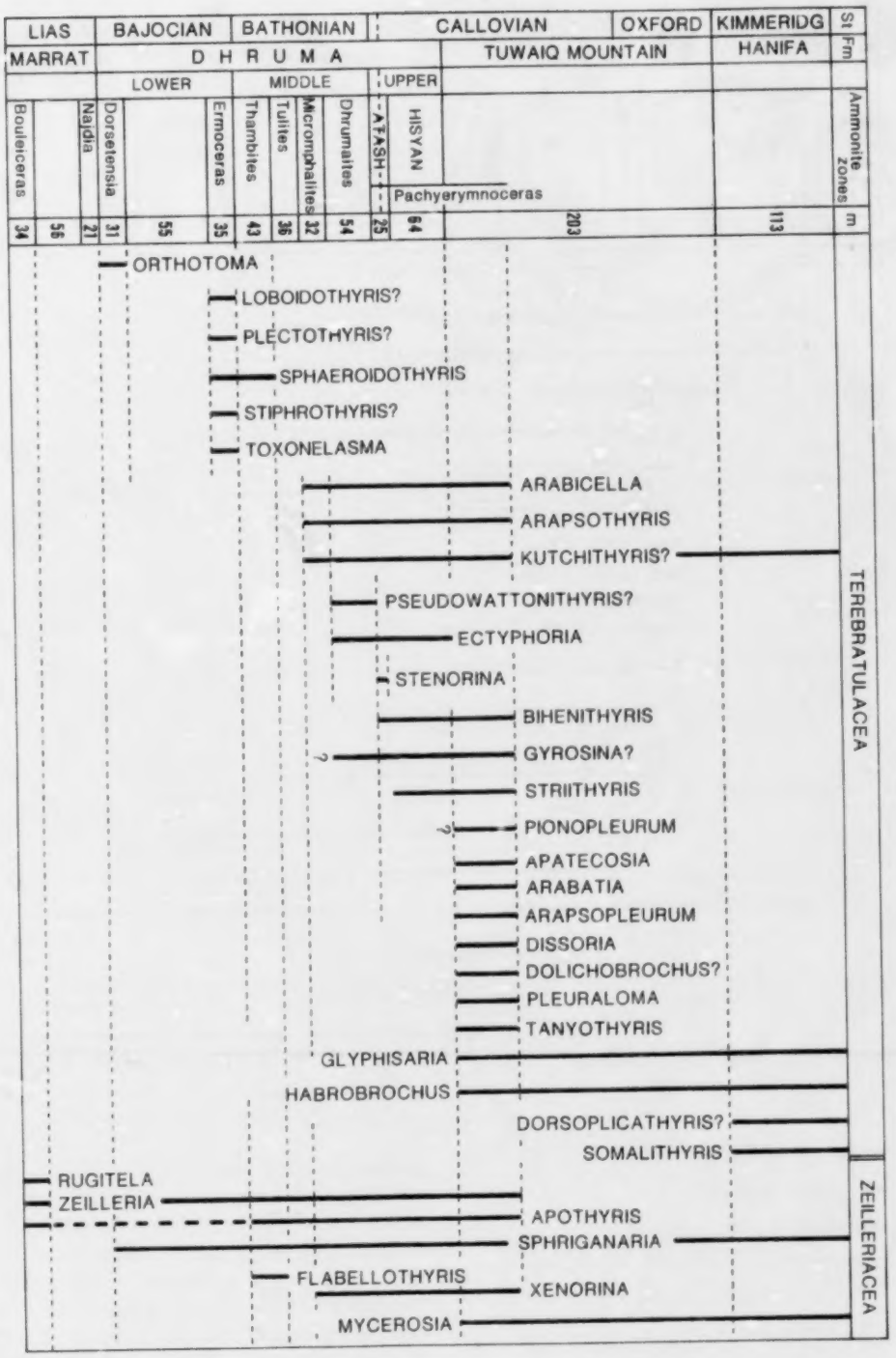


FIGURE 3.—Geological distribution of genera of Terebratulacea and Zeilleriacea. (*Avonothyris* could not be correctly placed).

Mountain, Hanifa, Jubaila, Arab, and Hith, the last mostly anhydrite. Brachiopods occur commonly in the lowest four formations. In the collection there are only two unidentifiable specimens from the Jubaila Formation and none from the upper two. Consequently, discussion of stratigraphic occurrences, herein is limited to the lowest four formations (Figures 2, 3).

The Marrat Formation is regarded as Early Jurassic (late Lias-Toarcian); the Dhruma Formation is said to be mostly Middle Jurassic with some Late Jurassic in the upper part. The Tuwaiq Mountain and Hanifa Formations are of Late Jurassic age. These formations are extensively discussed by Powers et al. (1966) from which the following information was taken.

MARRAT FORMATION.—The Marrat Formation has a maximum thickness of 111 m (364 ft). The type section is at Marah (Marrat) in the northern part of the Jurassic belt (lat. 25°04.5′N, long. 45°28.6′E). the lower Marrat consists of limestone and dolomite with layers of shale and calcareous quartz sandstone at the base. This lower part 34 m (112 ft) thick, contains the ammonite *Bouleiceras* and numerous spiriferinid brachiopods, as well as molluscs.

The middle Marrat, 56 m (184 ft) thick consists mostly of red silty shale with a few green strata without fossils. The upper Marrat is composed of light gray, dense limestone with some oolite and small amounts of clay shale at the base. The ammonites *Hildaites* and *Nejdia* occur for 21 m (69 ft).

According to Arkell (1952), the ammonites of the Marrat Formation indicate an early Toarcian age for the lower Marrat and a late Toarcian age for the upper beds (late Liassic).

DHRUMA FORMATION.—The Dhruma Formation is named for Dhruma (lat. 24°36′N, long. 46°07′E) and crops out in a broad arc extending from Al 'Arid (near 19°20′N) to Irgal Mazur (near 27°05′N) more than 900 km. It is 375 m (1230 ft) thick and is prominently exposed in the mid-portion of Saudi Arabia. Six ammonite zones have been identified.

The Lower Dhruma 120.8 m (396 ft) consists of shaly limestone, gypsum, and aphanitic limestone. The lowermost division is the *Dorsetensia* Zone 30.5 m (100 ft) thick. The upper zone of the Lower Dhruma 34.5 m (113 ft) is the *Ermoceras* Zone including the Dhibi Limestone Member 11 m (36 ft) thick.

The Middle Dhruma Formation consists mostly of calcarenitic limestone, calcarenite, and aphanitic limestone with four ammonite zones, from the bottom: *Thambites* Zone 43.2 m (142 ft); *Tulites* Zone 36.1 m (118 ft) thick; *Micromphalites* Zone 32. m (105 ft) thick; and *Dhrumaites* Zone 54 m (177 ft) thick. These four zones are placed in the Bathonian (Arkell, 1956; Imlay, 1970). Imlay shows the Bajocian occupying a lower portion of the *Thambites* Zone. Brachiopods occur in all four of these ammonite zones.

The Upper Dhruma 89 m (292 ft) consists of two members: the Atash Member below and the Hisyan Member above, same locality as the Atash Member. The Atash Member 25 m (82 ft) at Kashm al 'Atash (lat 24°10′50″N, long. 46°27′53″E) is composed of calcarenitic and aphanitic limestones containing a variety of brachiopods, among them the large *Arapsothyris*, new genus. The Hisyan Member 64 m (210 ft) is mostly shale. Both members are regarded as late Callovian in age (Lewy, 1983). Lewy (1983), Imlay (1970), and Kier (1972) recognize an unconformity at the top of the lower 11 m (36 ft) of the Atash Member. This is shown by an abrupt change in the echinoid fauna (Kier, 1972:8) and the presence of the ammonites *Erymnoceras, Pachyerymnoceras,* and *Erymnocerites* as indicated by Imlay (1970:D5, fig. 3) and Lewy (1983:10–11). Lewy places the upper 14 m (46 ft) of the Atash Member and the Hisyan Member in the late Callovian.

TUWAIQ MOUNTAIN FORMATION.—The type section is at Darb al Hyaz (Ar Riyadh-Jiddah road) measured through Hisyan Pass between 24°51′56″N, 46°07′10″E and 24°56′30″N, 46°13′32″E. The Tuwaiq Mountain Formation is a scarp-forming limestone 203 m (666 ft) thick that makes a prominent cliff above the Dhruma Formation and constitutes the backbone of the Jebel Tuwaiq. The ammonite *Erymnoceras* (*Pachyerymnoceras*) occurs in this formation and indicates a late Callovian to Oxfordian age.

HANIFA FORMATION.—The type section is at Wadi Hanifah, along an 8 km traverse from 24°57′24″N, 46°07′10″E to 24°56′36″N, 46°13′32″E. This formation is mostly limestone 113 m (371 ft) thick with colonial corals in the lower part and including some shale with pellet oolite. The Hanifa and overlying Jubaila Formation are dated as Kimmeridgian in age.

AMMONITE ZONES

The Mesozoic is divided into stages and minor subdivisions by means of the ammonites. These fossils have proved most useful for this purpose because they are geographically widespread and many are of limited vertical range. Under the section on guide fossils, Arkell (1956:13) stated: "Brachiopods are also helpful locally, but over wide areas they are disqualified because of their colonial habits, heavy dependence on facies and frequent homeomorphy." This statement is corroborated in this study; few brachiopod species described herein have wide areal distribution. However, within the confines of the Jurassic exposures in Saudi Arabia, they are useful biostratigraphic indicators.

Arkell (1952) established the ammonite zones in Saudi Arabia, two in the Liassic Marrat Formation: *Bouleiceras* and *Nejdia*; six in the Dhruma Fomation: *Dorsetensia, Ermoceras, Thambites, Tulites, Micromphalites,* and *Dhrumaites.* These zones are succeeded by the *Erymnoceras* (later *Pachyerymnoceras* Zone) Zone in the Tuwaiq Mountain Formation. Imlay (1970) extended the range of the *Erymnoceras* downward into the upper part (14 m) of the Atash Member of the Dhruma Formation.

Lewy (1983:10) discussed the ammonite zones of Saudi Arabia and revised Imlay's identification of *Erymnoceras philbyi* (Arkell) assigning this species to *Pachyerymnoceras.* He further points out that this genus appears first at 11 m (36 ft) above the base of the Atash Member of the Dhruma

Formation, extending through the overlying Hisyan Member of the Dhruma Formation into the lower 40 m (131 ft) of the Tuwaiq Mountain Formation, recognizing thereby that a discontinuity exists. He regards the unconformity at 11 m (36 ft) above the base of the Atash Member as the beginning of the upper Callovian. No ammonites have been reported from the Hanifa or Jubaila formations.

The unconformity indicated by ammonites and echinoids (Kier, 1972; Lewy, 1983) is crossed by some genera and species of brachiopods: *Apothyris aberrans*, new species, *Sphriganaria*, new genus, *Xenorina ovata*, new species, *Ectyphoria*, new genus, and *Somalirhynchia somalica* (Dacqué). The first appearance of *Striithyris* is in the Hisyan Member and the great flood of terebratulids in the Tuwaiq Mountain Formation, with elimination of most rhynchonellids, indicates a considerable faunal change above the Hisyan Member.

CORRELATION

The present state of the literature gives little help in correlating by brachiopods the Saudi Arabian sequence with other regions. Most of the brachiopods described from the Sinai, Israel, East Africa, and India are known mostly from exterior details or from lists; their correct generic identity in most cases is unknown. Most of the earlier studies were made before the general adoption of serial sectioning. The work of Buckman, which was the earliest attempt at sorting out Jurassic brachiopods, emphasized exterior characters and the nature of the dorsal muscle scars obtained by calcining the shells. His work, being the only source for genera available, was the chief reference and identification for the early workers in East Africa, the Sinai and other remote areas. Many of the Buckman names, based on British species, are still only poorly known generically. The only systematic attempt at sectioning the Buckman rhynchonellids is by Ager (1956-1967) on the British Liassic brachiopods and by Muir-Wood (1934). Cooper (1983) prepared the loops of a majority of the Buckman terebratulid genera.

Muir-Wood's (1935) monograph of the brachiopods of the Jurassic of British Somaliland is, at present, the only major modern work on the brachiopods of the Ethiopian Province. It is heavily relied upon and species of the Muir-Wood genera *Daghanirhynchia*, *Bihenithyris*, *Somalithyris*, and *Striithyris*, as well as *Somalirhynchia* Weir, appear in lists of Israeli Jurassic fossils by Hudson (1958) and in Saudi Arabia by Powers et al. (1966). The brachiopods identified with Buckman names in the Muir-Wood monograph in the absence of interior details, must be suspect; indeed all are queried by their author.

The generic names mentioned above and appearing in the Hudson and Powers et al faunal, lists appear correct, corroborated by the USNM collections of the Smithsonian's National Museum of Natural History. However, the species are not the same as those described from East Africa. *Striithyris africana*, Muir-Wood, 1935, is an example. The African species is very large, almost twice the size of that from Israel and Saudi Arabia. Furthermore, because the Muir-Wood (1935) monograph describes mostly Callovian forms, its usefulness in the study of the brachiopods of Saudi Arabia is limited.

As Arkell stated (1956:13), brachiopods are quite local and their species not widely disseminated. The Saudi Arabian brachiopods are highly endemic. In the absence of detailed studies of the Israel and Sinai brachiopods, correlation with those areas is only tenative and is mostly restricted to the Callovian. Kier (1972), in his study of the Jurassic echinoids of Saudi Arabia, encountered extreme endemism similar to that of the brachiopods. Of 27 identified echinoids, 24 proved to be new species; the three species already described had affinity with Somali forms.

That the brachiopods of Saudi Arabia have affinity with East Africa, Israel, and the Sinai is shown by the common presence in the Callovian and later beds of *Daghanirhynchia*, *Somalirhynchia*, *Bihenithyris*, *Somalithyris* and *Striithyris*, though in most cases the species are not the same, except for *Somalirhynchia africana* Weir and *S. somalica* (Dacqué). Of the numerous species of *Eudesia* (now *Sphriganaria*) described by Farag, only one (*S. magharensis*) was identified in Saudi Arabia where it has a fairly long range.

Recognition of *Somalirhynchia* in Tunisia (Dubar, 1967) provides a link to Saudi Arabia and the Somali Republic. Other rhynchonellids described by Dubar are strongly suggestive of *Daghanirhynchia*, as described herein. The undivided hinge plate in the type species of *Daghanirhynchia* appears anomalous and is not seen in species that in every other character are similar to *Daghanirhynchia*. *Somalirhynchia* has been identified in Scotland and Russia (Childs, 1969).

More precise correlations throughout the Jurassic sequence have been made on the basis of ammonites (Arkell, 1952; Imlay, 1970; Lewy, 1983). Attempt is made here to relate the brachiopods to the ammonite zones. Future work on the brachiopods of the Sinai and Israel by a team of American, Israeli, and British paleobiologists, with abundant stratigraphically well-established specimens, may possibly reveal closer affinities. The occurrence of *Septirhynchia* (Muir-Wood, 1935) in Ethiopia, Somali Republic, the Sinai (Feldman, 1987), and Tunisia (Mancenido and Walley, 1979) suggests a relationship among these areas in the Callovian, but the genus is so far missing in Saudi Arabia.

List of Species Described from Saudi Arabia

Superfamily RHYNCHONELLACEA Gray, 1848
- Family RHYNCHONELLIDAE Gray, 1848
  - Genus *Amydroptychus*, new genus
    - *Amydroptychus formosus*, new species
  - Genus *Baeorhynchia*, new genus
    - *Baeorhynchia carinata*, new species
    - *Baeorhynchia cuneata*, new species
    - *Baeorhynchia elegantula*, new species

Baeorhynchia nitida, new species
Baeorhynchia nucleata, new species
Baeorhynchia transversa, new species
Genus *Burmirhynchia* Buckman, 1917
Burmirhynchia angustata, new species
Burmirhynchia? bicostata, new species
Burmirhynchia cuneata, new species
Burmirhynchia decorticata, new species
Burmirhynchia rostrata, new species
Burmirhynchia subnasuta, new species
Genus *Colpotoria*, new genus
Colpotoria magna, new species
Colpotoria plicatilis, new species
Genus *Conarosia*, new genus
Conarosia angustata, new species
Conarosia concinna, new species
Conarosia matutina, new species
Conarosia medialis, new species
Conarosia ovata, new species
Conarosia rotundata, new species
Conarosia sphenoidea, new species
Conarosia species
Genus *Cymatorhynchia* Buckman, 1917
Cymatorhynchia? singularis, new species
Genus *Daghanirhynchia* Muir-Wood, 1935
Daghanirhynchia angulocostata, new species
Daghanirhynchia sulcata, new species
Daghanirhynchia? triangulata, new species
Genus *Deltarhynchia*, new genus
Deltarhynchia compacta, new species
Deltarhynchia triangulata, new species
Genus *Echyrosia*, new genus
Echyrosia circularis, new species
Echyrosia costata, new species
Echyrosia expansa, new species
Genus *Eurysites*, new genus
Eurysites rotundus, new species
Eurysites transversus, new species
Genus *Gibbirhynchia* Buckman, 1917
Gibbirhynchia costata, new species
Gibbirhynchia magna, new species
Gibbirhynchia mundula, new species
Gibbirhynchia parva, new species
Gibbirhynchia pulcher, new species
Gibbirhynchia rotundata, new species
Gibbirhynchia sphaerica, new species
Gibbirhynchia subcircularis, new species
Genus *Globirhynchia* Buckman, 1917
Globirhynchia concinna, new species
Globirhynchia? crassa, new species
Globirhynchia? dubia, new species
Globirhynchia subtriangulata, new species
Globirhynchia triangulata, new species
Genus *Heteromychus*, new genus
Heteromychus magnificus, new species
Heteromychus? species
Genus *Kallirhynchia* Buckman, 1917
Kallirhynchia arabica, new species
Kallirhynchia dispar, new species
Kallirhynchia obesa, new species
Kallirhynchia orbicularis, new species
Genus *Kutchirhynchia* Buckman, 1917
Kutchirhynchia arabica, new species
Genus *Lirellarina*, new genus
Lirellarina costellata, new species
Genus *Nastosia*, new genus
Nastosia coangustata, new species
Nastosia? convexa, new species
Genus *Pycnoria*, new genus
Pycnoria compacta, new species
Pycnoria magna, new species
Genus *Schizoria*, new genus
Schizoria costellata, new species
Schizoria dividicostata, new species
Schizoria elongata, new species
Schizoria intercalata, new species
Schizoria intermedia, new species
Schizoria rotundata, new species
Schizoria secta, new species
Schizoria species 1
Schizoria species 2
Genus *Somalirhynchia* Weir, 1925
Somalirhynchia africana Weir
Somalirhynchia arabica, new species
Somalirhynchia deficiens, new species
Somalirhynchia prearabica, new species
Somalirhynchia somalica (Dacqué)
Genus *Sphenorhynchia* Buckman, 1917
Sphenorhynchia? angulata, new species
Sphenorhynchia varicostata, new species
Genus *Strongyloria*, new genus
Strongyloria circularis, new species
Strongyloria subelliptica, new species
Genus *Torquirhynchia* Childs, 1969
Torquirhynchia? convexa, new species
Torquirhynchia? parva, new species
Rhynchonellacean Genus and Species Undetermined
Superfamily SPIRIFERINACEA Davidson, 1884
Family SPIRIFERINIDAE Davidson, 1884
Genus *Calyptoria*, new genus
Calyptoria carinata, new species
Calyptoria extensa, new species
Genus *Liospiriferina* Rousselle, 1977
Liospiriferina obesa, new species
Liospiriferina vulgata, new species
Genus *Spiriferina* d'Orbigny, 1847
Spiriferina species 1
Spiriferina species 2
Spiriferina species 3

Superfamily TEREBRATULACEA Gray, 1840
Family ORTHOTOMIDAE Muir-Wood, 1936
Genus *Orthotoma* Quenstedt, 1869
Orthotoma? species
Family TEREBRATULIDAE Gray, 1840
Genus *Apatecosia* Cooper, 1983
Apatecosia inornata, new species
Apatecosia varians, new species
Genus *Arabatia*, new genus
Arabatia concava, new species
Genus *Arabicella*, new genus
Arabicella? costata, new species
Arabicella ovalis, new species
Arabicella subpentagonalis, new species
Arabicella subplana, new species
Genus *Arapsopleurum*, new genus
Arapsopleurum arabicum, new species
Arapsopleurum dubium, new species
Arapsopleurum rotundum, new species
Genus *Arapsothyris*, new genus
Arapsothyris angustata, new species
Arapsothyris magna, new species
Genus *Avonthyris* Buckman, 1917
Avonothyris? species
Genus *Bihenithyris* Muir-Wood, 1935
Bihenithyris? abnormis, new species
Bihenithyris deformata, new species
Bihenithyris mediocostata, new species
Bihenithyris quadrilobata, new species
Bihenithyris simulans, new species
Bihenithyris triangulata, new species
Bihenithyris species
Genus *Dolichobrochus* Cooper, 1983
Dolichobrochus? ovatus, new species
Genus *Dorsoplicathyris* Almeras, 1971
Dorsoplicathyris? species
Genus *Ectyphoria*, new genus
Ectyphoria inflata, new species
Genus *Glyphisaria* Cooper, 1983
Glyphisaria? divergens, new species
Glyphisaria? species
Genus *Gyrosina* Cooper, 1983
Gyrosina? ovata, new species
Gyrosina? species
Genus *Habrobrochus* Cooper, 1983
Habrobrochus amygdaloideus, new species
Genus *Loboidothyris* Buckman, 1917
Loboidothyris? species
Genus *Pionopleurum*, new genus
Pionopleurum compactum, new species
Pionopleurum obesum, new species
Genus *Plectothyris* Buckman, 1917
Plectothyris? species
Genus *Pleuraloma*, new genus
Pleuraloma abruptum, new species
Pleuraloma anomalum, new species
Pleuraloma? circulare, new species
Pleuraloma convexum, new species
Pleuraloma labiatum, new species
Pleuraloma multicostatum, new species
Pleuraloma robustum, new species
Pleuraloma subaequicostatum, new species
Pleuraloma triangulatum, new species
Pleuraloma varicostatum, new species
Pleuraloma species
Genus *Pseudowattonithyris* Almeras, 1971
Pseudowattonithyris? species
Genus *Somalithyris* Muir-Wood, 1935
Somalithyris elliptica, new species
Somalithyris ovata, new species
Somalithyris parva, new species
Somalithyris rotundata, new species
Somalithyris subcircularis, new species
Somalithyris triangulata, new species
Genus *Sphaeroidothyris* Buckman, 1917
Sphaeroidothyris arabica, new species
Sphaeroidothyris sphaeroidalis (Auct.)
Sphaeroidothyris species 1
Sphaeroidothyris species 2
Genus *Stenorina*, new genus
Stenorina parallela, new species
Genus *Stiphrothyris* Buckman, 1917
Stiphrothyris? species 1
Stiphrothyris? species 2
Genus *Striithyris* Muir-Wood, 1935
Striithyris costata, new species
Striithyris saudiarabica, new species
Striithyris striata, new species
Genus *Tanyothyris*, new genus
Tanyothyris angustata, new species
Tanyothyris symmetrica, new species
Genus *Toxonelasma*, new genus
Toxonelasma arabicum, new species
Family Uncertain
Genus *Dissoria*, new genus
Dissoria costata, new species
Dissoria obscura, new species
Dissoria tribulis, new species
Genus *Kutchithyris* Buckman, 1917
Kutchithyris? species 1
Kutchithyris? species 2
Terebratulacean Genus and Species Undetermined 1
Terebratulacean Genus and Species Undetermined 2
Terebratulacean Genus and Species Undetermined 3
Superfamily ZEILLERIACEA Allan, 1940
Family EUDESIIDAE Muir-Wood, 1965
Genus *Apothyris*, new genus
Apothyris aberrans, new species
Apothyris species
Genus *Sphriganaria*, new genus

Sphriganaria angulocostata, new species
Sphriganaria angustata, new species
Sphriganaria arguta, new species
Sphriganaria bicostata, new species
Sphriganaria bramkampi, new species
Sphriganaria capax, new species
Sphriganaria concentrica, new species
Sphriganaria costata, new species
Sphriganaria costellata, new species
Sphriganaria curtirostra, new species
Sphriganaria distans, new species
Sphriganaria distincta, new species
Sphriganaria elliptica, new species
Sphriganaria eximia, new species
Sphriganaria expansa, new species
Sphriganaria intercalata, new species
Sphriganaria irregularis, new species
Sphriganaria lirata, new species
Sphriganaria magharensis (Farag), new combination
Sphriganaria magnicostata, new species
Sphriganaria modesta, new species
Sphriganaria nasuta, new species
Sphriganaria obesa, new species
Sphriganaria parva, new species
Sphriganaria perovalis, new species
Sphriganaria rara, new species
Sphriganaria subcircularis, new species
Sphriganaria varicostata, new species
Sphriganaria species 1
Sphriganaria species 2
Genus *Xenorina*, new genus
Xenorina ovata, new species
Family ZEILLERIIDAE Allan, 1940
Genus *Flabellothyris* E. Eudes-Deslongchamps, 1884
Flabellothyris flabella (Defrance)
Genus *Mycerosia*, new genus
Mycerosia amygdaliformis, new species
Genus *Rugitela* Muir-Wood, 1936
Rugitela primaria, new species
Genus *Zeilleria* Bayle, 1878
Zeilleria species 1
Zeilleria species 2

Superfamily RHYNCHONELLACEA Gray, 1848

Family RHYNCHONELLIDAE Gray, 1848

Subfamily TETRARHYNCHIINAE Ager, 1965

The rhynchonellaceans of the Jurassic of Saudi Arabia form an interesting and varied group ranging in size from the small *Baeorhynchia* to the large *Heteromychus* and *Conarosia*. Many have the characteristics of the "common or ordinary" rhynchonellid, i.e., triangular shape, strong costation, and are uniplicate. No smooth, sulcate, medianly carinate, or semicostate rhynchonellaceans were found in the collection. In addition to the common rhynchonellid form and costation, specimens with fine costae or costellae are fairly common. Genera with intercalated and bifurcated costae or costellae, usually rare among the Rhynchonellacea, occur in the Lower Dhruma Formation (*Ermoceras* Zone).

In describing beak structures and beak curvature, the terms proposed by Thompson (1927) are used. The beak structures commonly seen in rhynchonellid brachiopods are usual among the Saudi Arabian species except in those genera that are spherical, or nearly so. In these species, there is a tendency to reduction and possible elimination of the pedicle as shown by a small or minute foramen, a tubular pedicle passage formed by close approximation of the deltidial plates, and development of a thick pedicle collar. Examples are some species of *Schizoria*, *Conarosia*, *Amydroptychus*, and *Gibbirhynchia*, all rotund to spherical genera.

The Marrat Formation produced only one rhynchonellid in the collection, a single specimen of the large *Conarosia*. Rhynchonellids are reported in the field records at some localities of the Marrat Formation, but these are not in the present collection studied. Rhynchonellaceans are common in the Dhruma Formation, especially in the *Ermoceras* and *Thambites* zones. They decline in numbers in the *Tulites* Zone and more so in the *Micromphalites* Zone. They are much diminished in numbers in the *Dhrumaites* Zone and the Upper Dhruma Formation.

In the Tuwaiq Mountain Formation, the number of rhynchonellids is far outweighed by the abundance of terebratulids. The Hanifa Formation yielded only four rhynchonellids.

Two features of rhynchonellid anatomy used by Ager (1965), in the family Cyclothyridinae are the rimmed circular foramen and the canalifer type of crura. Not one of the Saudi Arabian rhynchonellids shows these characters. In most genera described herein, the deltidial plates have marginal rims, but in none of them do the rims close posteriorly and anteriorly to form a ring, as is characteristic of the Cyclothyridinae. *Daghanirhynchia*, *Globirhynchia*, and *Sphenorhynchia* are classified in the Cyclothyridinae (Ager 1965:H614), but they do not show this feature of the deltidial plates. Specimens of *Daghanirhynchia* in the USNM collections have rimmed deltidial plates, but the rims do not form a circle.

In the serial sections of *Daghanirhynchia* given by Muir-Wood (1935:95), the crura are not shown, the sections ending at the distal end of the hinge plates. Serial sections of *Daghanirhynchia angulocostata* new species (Figure 14) show radulifer crura. Almeras (1980) shows the crura of *Sphenorhynchia* to be radulifer and his illustrations show a rimmed, but not circular, structure of the deltidial plates. He recommends that the genus be placed in the Tetrarhynchiinae of Ager (Almeras, 1980:328). Figures of *Globirhynchia* in the Treatise (Ager, 1965:H616, fig. 499-2a) show a tubular foramen. However, specimens of the type species *G. subobsoleta* (Davidson) in the USNM collections have rimmed deltidial

plates. However, the rims do not close to form a circle or tube. All three of these genera belong in the Tetrarhynchiinae rather than in the Cyclothyridinae.

Of the 23 rhynchonellid genera described herein, 13 are new and 10 are established: *Burmirhynchia, Cymatorhynchia, Daghanirhynchia, Gibbirhynchia, Globirhynchia, Kallirhynchia, Kutchirhynchia, Somalirhynchia, Sphenorhynchia,* and *Torquirhynchia.* The first is widespread and is known from Burma, Europe, Great Britain and Africa (Kenya, Somali Republic, and Tunisia). *Cymatorhynchia, Gibbirhynchia, Globirhynchia, Kallirhynchia, Sphenorhynchia,* and *Torquirhynchia* are best known from Great Britain and Europe. *Daghanirhynchia* and *Somalirhynchia* were first described from East Africa. The range of both has been extended, the former to Israel and the latter to Scotland, Russia, and Tunisia. There are also specimens of the latter from Sinai in the USNM collections. The type species of *Kutchirhynchia* is poorly known.

These occurrences give slim help in correlation. *Colpotoria, Conarosia,* and *Heteromychus,* all new genera, are unusually large rhynchonellids that appear to be unique to Saudi Arabia. The cardinal process of *Heteromychus* is unlike that of any other rhynchonellid, most of which do not have a cardinal process. *Amydroptychus* and *Strongyloria,* new genera, with their rounded outlines and gentle folding are not known elsewhere. *Nastosia* is unusual for its narrowly spaced, nearly parallel dental plates.

Echyrosia, new genus, suggests *Prionorhynchia* Buckman, 1917, but is a younger and internally different rhynchonellid. *Eurysites,* new genus, suggests *Flabellirhynchia* Buckman, 1917. *Eurysites* is younger in occurrence and different in exterior and interior characters, ranging from Bathonian to Callovian, not Bajocian like the British species. Bifurcated and intercalated costae are unusual in the Rhynchonellacea. The two Bajocian genera *Lirellarina* and *Schizoria,* new genera, are quite unlike any described rhynchonellid, because of their divided or intercalated costae or costellae. *Baeorhynchia,* new genus, suggests certain smaller rhynchonellids, such as *Rhychonelloidea* Buckman, 1917, and *Rhychonelloidella* Muir-Wood, 1936, but it is completely costate. *Deltarhynchia* new genus, is similar to "*Rhynchonella*" *subdecorata* Davidson (1851–1852) from the Inferior Oolite (Bajocian) of Great Britain. There are specimens from Sinai like it in the USNM collections.

The established genera recognized in Saudi Arabia are not all in accordance with their previously established ranges. The range of *Burmirhynchia,* if the earliest species so identified in Saudi Arabia is truly a burmirhynchiid, will be extended downward into the upper Bajocian. *Gibbirhynchia,* as identified here, ranges from Bajocian well into the Bathonian. *Kallirhynchia* has a long range from mid-Bathonian into the Callovian. *Sphenorhynchia* is restricted to the Bajocian and Bathonian. *Torquirhynchia,* represented by only two specimens, ranges from Callovian to Kimmeridgian. *Somalirhynchia* ranges from Bathonian to Kimmeridgian. *Daghanirhynchia,* confined to the Callovian in East Africa, ranges from Bathonian to Callovian in Saudi Arabia.

Classification of the Order Rhynchonellida has proved a difficult task and, at present, the results are unsatisfactory. There is no consensus or agreement on the characters to be used and the weight to be given them. Although the type of crura has been used as a criterion with some success in the Recent brachiopods and is used, in part, by Ager to separate the Tetrarhynchiinae and Cyclothyridinae, it has not been used in the classification of the Paleozoic rhynchonellids. Ager has repeatedly noted the tentative nature of the present classification. Since the appearance of the classification in the American Treatise (Ager, 1965), genera have been shifted from the Cyclothyridinae with canalifer crura to the Tetrarhynchiinae with radulifer crura. As noted above, three of the Cyclothyridinae, *Daghanirhynchia, Globirhynchia,* and *Sphenorhynchia,* have radulifer crura and must be transferred to the Tetrarhynchiinae. All ten established genera identified herein belong to the Tetrarhynchiinae. The 13 newly described genera all have radulifer crura and are also assigned to the Tetrarhynchiinae. Not one of them has a circular rimmed foramen, one of the requisites for inclusion in the Cyclothyidinae.

Amydroptychus, new genus

TYPE SPECIES.—*Amydroptychus formosus,* new species.

DIAGNOSIS.—Medium, widely, roundly triangular. Anterior commissure rectimarginate to slightly arcuately uniplicate. Beak small, foramen small, tubular, hypothyridid. Deltidial plates disjunct. Costae subangular, occasional intercalations on umbones. Dental plates short; septalium small; median septum short. Crura radulifer, laterally expanded distally.

SPECIMENS STUDIED.—Nine.

GEOLOGIC OCCURRENCE.—Bajocian (*Ermoceras* Zone).

ETYMOLOGY.—Greek *amydros* (indistinct) plus *ptychos* (fold), in allusion to the poor development of fold and sulcus.

DISCUSSION.—The lack of a pronounced fold distinguishes this genus. It differs from *Nastosia,* new genus, which is gently folded, in a more rounded outline, more numerous costae, in the wider spacing of the dental plates, and shorter median septum.

Amydroptychus is not so plump and is more triangular than *Strongyloria,* new genus, and has a much different interior, especially the less prominent septalium.

Amydroptychus formosus, new species

FIGURE 4; PLATE 1: FIGURES 1–15

DIAGNOSIS.—*Amydroptychus* with rounded, triangular outline, small foramen and poorly developed fold and sulcus.

DESCRIPTION.—Medium, widely subtriangular; maximum width anterior to midvalve. Inequivalve, dorsal valve slightly

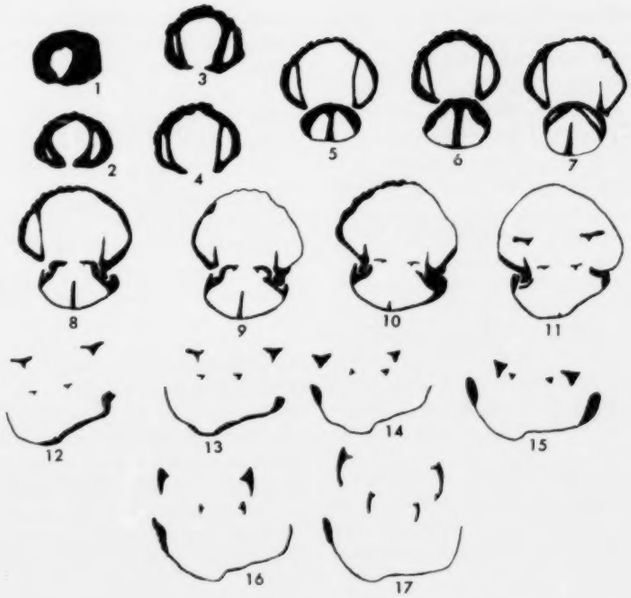


FIGURE 4.—*Amydroptychus formosus*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.7(0.7); 2, 0.6(1.3); 3, 0.3(1.6); 4, 0.4(2.0); 5, 0.4(2.4); 6, 0.4(2.8); 7, 0.4(3.2); 8, 0.1(3.3); 9, 0.2(3.5); 10, 0.2(3.7); 11, 0.2(3.9); 12, 0.3(4.2); 13, 0.3(4.5); 14, 0.2(4.7); 15, 0.2(4.9); 16, 0.2(5.1); 17, 0.3(5.4). Approximately ×2; crura end at 5.6 mm from beak; length 17.0 mm; USNM 380683; Locality S1409.

more convex and deeper than ventral valve. Apical angle acute. Lateral commissure straight; anterior commissure rectimarginate to gently, arcuately uniplicate. Beak fairly long, erect; foramen small, tubular; deltidial plates disjunct with marginal rims. About 20 subangular thick costae, separated by striae narrower than costae; intercalation of costae on umbones rare.

Ventral valve gently convex in side view; broadly, gently domed in anterior profile. Median region swollen. Sulcus very shallow with 4 or 5 costae slightly depressed below flanks in anterior third. Tongue broad, short. Flanks gently convex.

Dorsal valve moderately convex in side view, broadly domed with moderately sloping sides in anterior view. Entire valve swollen with barely perceptible fold having 5 or 6 costae. Fold slightly elevated in anterior half.

Interior: Ventral valve with short dental plates; short low median myophragm between dental plates in some specimens.

Dorsal valve interior with small short, thick septalium and short median septum occupying 1/5 valve surface length. Crural bases well-formed; crura long, radulifer, distally expanded.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate fold was not developed and could not be measured.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Anical angle*	*Fold width*
360223a	22.0	19.0	21.8	25.3	85	10.0
380223b	22.8	19.6	21.9	15.5	85	11.0
380223c	19.2	17.4	21.0	15.7	87	?
380223d	17.4	15.5	18.2	12.4	87	7.0
380223e	16.4	14.7	16.9	11.6	87	?

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1409.

TYPES.—Holotype: USNM 380223c. Paratypes: USNM 380223a,b,d,e, 380683.

DISCUSSION.—This species in its exterior resembles *Strongyloria circularis*, new species. It is, however, more triangular, than circular in outline and with a narrower beak than that of *Strongyloria*. The gentle folding is a conspicuous feature of *Amydroptychus*.

Baeorhynchia, new genus

TYPE SPECIES.—*Baeorhynchia nucleata*, new species.

DIAGNOSIS.—Small, triangular, uniplicate, beak erect to suberect, completely costate. Dental plates short, septalium, small, narrow; median septum long; crura radulifer.

SPECIMENS STUDIED.—38.

GEOLOGICAL OCCURRENCE.— Bajocian to Bathonian (*Thambites* Zone).

ETYMOLOGY.—Greek, *baios* (small, scanty) plus *rhynchos* (beak).

DISCUSSION.—This genus has the appearance of the small, common rhynchonellid in its complete costation and strong fold and sulcus. It is suggestive of such small genera as *Rhynchonelloidea*, *Curtirhynchia* both Buckman (1917) and *Rhynchonelloidella* Muir-Wood (1936). It differs from the first two in being completely costate and from *Rhynchonelloidella* in having a narrower fold and sulcus, and long median septum and radulifer crura.

There is variability in the length of the dental plates in this genus, those in the Lower Dhruma (*Dorsetensia* Zone) being somewhat shorter than those of the *Thambites* Zone. Otherwise the species share similar internal characters that are variable in slight degree.

Baeorhynchia carinata, new species

PLATE 1: FIGURES 16–21

DIAGNOSIS.—Finely costate *Baeorhynchia* with very narrow fold.

DESCRIPTION.—Medium for genus, subtriangular, with maximum width at anterior. Anterior margin straight, sides rounded, apical angle acute. Lateral commissure oblique; anterior commissure narrowly uniplicate. Beak low, short; foramen very small; deltidial plates wide, thick almost conjunct. Costae narrowly rounded, numerous, about 25.

Ventral valve slightly convex in side view, somewhat narrowly sulcate in anterior profile with narrow flanks. Umbonal region swollen. Sulcus originating at midvalve, narrow, deep, with 3 strong median costae, two lateral poorly defined ones. Tongue long, narrow.

Dorsal valve flatly convex in lateral profile; narrowly domed with convex steep sides. Valve swollen. Fold originating at about midvalve, narrowly rounded, with 5 costae; strongly elevated at anterior.

Interior not known.

MEASUREMENTS (in mm).—USNM 380268: length 11.0; dorsal valve length 9.5; width 10.8; thickness 7.9; fold width 4.0.

OCCURRENCE.—Lower Dhruma Formation (74–83 m above base between *Dorsetensia* and *Ermoceras* zones): S996.

TYPE.—Holotype: USNM 380268.

DISCUSSION.—This species differs from *B. nitida*, new species, in its finer costation, and extremely narrow fold. The narrow fold distinguishes this species from all others except *B. cuneata*, which has a narrower form and much stronger costae than *B. carinata*.

Baeorhynchia cuneata, new species

PLATE 1: FIGURES 22–27

DIAGNOSIS.—Wedge-shaped *Baeorhynchia* with narrow fold and sulcus.

DESCRIPTION.—Small, laterally compressed with strongly unequal valves. Dorsal valve deeper, more convex than ventral valve. Sides rounded, anterior truncate, apical angle acute. Strongly, narrowly uniplicate. Beak incurved, foramen oval deltidial plates concealed. Costae strong, rounded, separated by striae narrower than costae, numbering about 16.

Ventral valve gently convex with narrowly convex umbo in side view; anterior view narrowly sulcate. Umbonal region swollen. Sulcus starting posterior of midvalve, deeply inset between narrowly convex flanks. Sulcus with 4 costae, outer 2 against inner wall of sulcus. Tongue long, narrow, pointed.

Dorsal valve moderately convex in side view; narrowly domed with apex subangular in anterior view. Fold originating posterior of midvalve, moderately elevated above narrow, steep flanks.

Interior not seen.

MEASUREMENTS (in mm).—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380263a	12.0	10.0	10.0	11.2	75	4.6
380263b	12.0	10.6	11.6	11.4	77	4.4

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK6, KK7-45.

TYPES.—Holotype: USNM 380263a. Paratypes: USNM 380263b,c.

DISCUSSION.—The narrow, laterally compressed form and cuneate fold readily separate this species from other *Baeorhynchia* described herein.

Baeorhynchia elegantula, new species

PLATE 1: FIGURES 28–33

DIAGNOSIS.—Subpentagonal *Baeorhynchia* with strongly rounded fold with 5 costae.

DESCRIPTION.—Small, subpentagonal, maximum width just anterior of midvalve. Sides rounded, anterior margin nearly straight, apical angle obtuse. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak low, erect; foramen small; deltidial plates narrow, disjunct with marginal rims. Costae narrow, subangular, numbering about 25.

Ventral valve flatly convex in side view, flatly concave in anterior profile. Sulcus wide, originating on umbo, deep anteriorly, occupied by 4 costae. Flanks narrowly rounded, steep. Tongue long.

Dorsal valve gently convex in side view, narrowly domed in anterior profile. Fold starting anterior to umbo, narrowly rounded, strongly elevated, with 5 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380499: length 12.8, dorsal valve length 11.0, width 12.3, thickness 9.6, apical angle 97°, fold width 7.4.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1503.

TYPES.—Holotype: USNM 380499.

DISCUSSION.—The costation of this species suggests that of *B. nucleata*, new species. It differs in having a wider apical angle, rounded fold, and 4 costae in the sulcus. For comparison with *B. transversa*, new species, see discussion of that species.

Baeorhynchia nitida, new species

FIGURE 5; PLATE 1: FIGURES 34–51

DIAGNOSIS.—Small, subtriangular, variable with maximum width anterior of midvalve. Anterior margin nearly straight to gently rounded, sides narrowly rounded, apical angle acute. Anterior commissure strongly uniplicate. Beak short, low, erect. Foramen small, narrow; deltidial plates disjunct with marginal rims. Costae narrowly rounded, strong, about 17–25.

Ventral valve flatly convex in lateral view, fairly strongly sulcate in anterior view. Sulcus originating near midvalve, deepening rapidly, with 2-4 costae, strongly depressed below narrowly rounded flanks. Tongue long, narrow, pointed.

Dorsal valve gently convex in lateral view, strongly domed with steep sides in anterior profile. Fold narrowly rounded, originating at midvalve with 4 or 5 costae.

Interior: Shell thick in posterior region of both valves. Dental plates extending in section about 1/5 valve length (about 1/3 surface length). Septalium small, median septum proximally thick, extending about 1/4 interior valve length (nearly reaching midvalve on exterior as seen through shell). Crural bases not formed; crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380267a	13.7	11.4	13.0	11.0	82	6.4
380267b	13.0	11.0	13.3	11.4	84	6.0
380518a	11.2	10.0	11.0	8.0	88	5.4
380518b	11.2	10.3	10.6	8.7	86	5.5

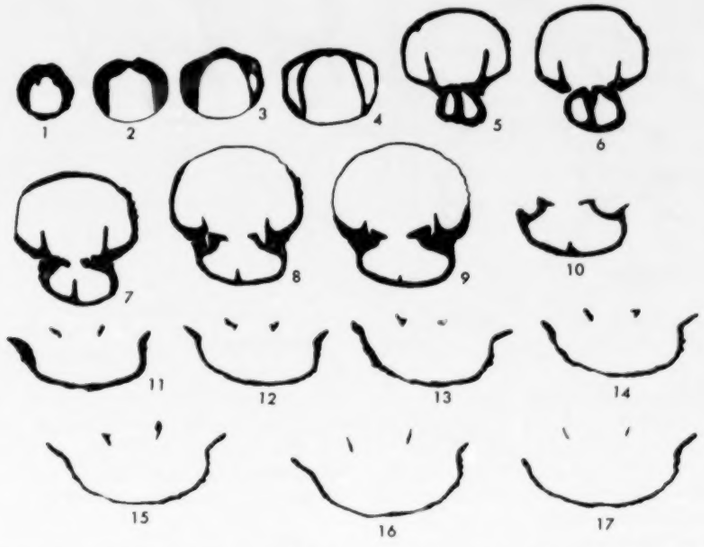


FIGURE 5.—*Baeorhynchia nitida*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.4(0.4); 2, 0.4(0.8); 3, 0.2(1.0); 4, 0.3(1.3); 5, 0.3(1.6); 6, 0.1(1.7); 7, 0.2(1.9); 8, 0.2(2.1); 9, 0.1(2.2); 10, 0.2(2.4); 11, 0.1(2.5); 12, 0.1(2.6); 13, 0.1(2.7); 14, 0.1(2.8); 15, 0.2(3.0); 16, 0.2(3.2); 17, 0.1(3.3). Approximately ×3; length 10.0 mm; USNM 380676; Locality KK7-39.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK6, KK7-35, KK7-39; (between *Dorsetensia* and *Ermoceras* zones): S996.

TYPES.—Holotype: USNM 380267a. Paratypes: USNM 380267b,c,d, 380518a–f, 380676.

DISCUSSION.—This species differs from *B. elegantula*, new species, in having stronger costae and narrower fold. It is not so narrow nor so narrowly folded as *B. cuneata*, new species. *Baeorhynchia nitida* differs from *B. carinata*, new species, in being larger, wider, and with stronger costae. *Baeorhynchia nitida* differs from *B. nucleata*, new species, in its narrower, more elevated fold, narrower sulcus, more triangular outline, more erect beak, and in the length of the dental plates.

Baeorhynchia nucleata, new species

FIGURE 6; PLATE 2: FIGURES 7–12

DIAGNOSIS.—Large for genus with few strong costae.

DESCRIPTION.—Subtriangular, maximum width anterior of midvalve. Sides rounded, apical angle acute. Lateral commissure oblique; anterior commissure uniplicate. Beak short, suberect; foramen large; deltidial plates disjunct, thickened. Costae subangular, numbering 12–15.

Ventral valve gently convex in side view, medially gently concave in anterior profile. Umbonal region convex. Sulcus originating posterior of midvalve, shallow, occupied by 2 or 3 costae, deepening anteriorly; bounded by moderately elevated flanks. Tongue long, narrowly rounded.

Dorsal valve moderately convex in lateral view, domed with steep sides in anterior profile. Umbonal and median regions swollen. Fold originating posterior to midvalve, moderately elevated above flanks in anterior third. Fold occupied by 3 or 4 costae.

Interior: Ventral valve with dental plates extending 1/3 valve surface length.

Dorsal valve interior with small, narrow septalium and median septum nearly reaching midvalve.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380264a	13.5	11.5	12.5	9.0	84	6.8
380264b	12.2	10.01	11.8	8.7	80	4.0

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1503.

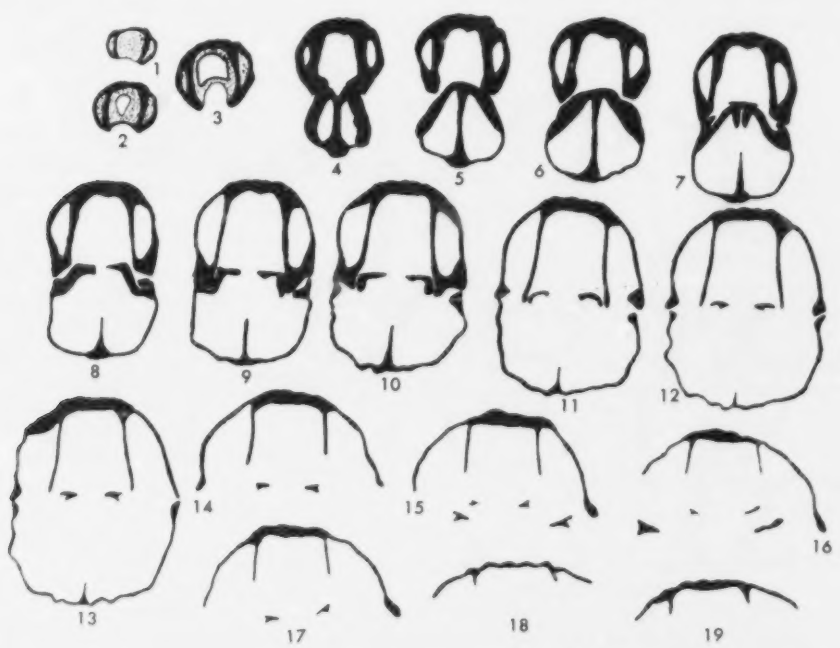


FIGURE 6.—*Baeorhynchia nucleata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.3(0.3); 2, 0.4(0.7); 3, 0.4(1.1); 4, 0.2(1.3); 5, 0.2(1.5); 6, 0.2(1.7); 7, 0.1(1.8); 8, 0.2(2.0); 9, 0.2(2.2); 10, 0.1(2.3); 11, 0.2(2.5); 12, 0.2(2.7); 13, 0.2(2.9); 14, 0.3(3.2); 15, 0.1(3.3); 16, 0.1(3.4); 17, 0.3(3.7); 18, 0.3(4.0); 19, 1.0(5.0). Approximately ×3.5; length 9.5 mm; USNM 380675; Locality S1503.

TYPES.—Holotype: USNM 380264a; paratype: USNM 380264b, 380675.

DISCUSSION.—This species is larger than other species of *Baeorhynchia* described herein, except *B. nitida*, and has a somewhat longer beak and longer dental plates. (See discussion under *B. nitida*.)

Baeorhynchia transversa, new species

PLATE 2: FIGURES 1–6

DIAGNOSIS.—Wide, finely costate *Baeorhynchia*.

DESCRIPTION.—Widely triangular, maximum width at about midvalve. Sides rounded, apical angle obtuse. Lateral commissure oblique; anterior commissure narrowly uniplicate. Beak short; foramen small, oval; deltidial plates disjunct with elevated rims. Costae subangular, numbering 28.

Ventral valve flatly convex in side view, broadly and moderately concave in anterior view. Sulcus originating posterior of midvalve, wide, depressed below flanks strongly at anterior, occupied by 5 costae, lateral 2 poorly seen on sides of sulcus. Tongue long, narrow, narrowly rounded.

Dorsal valve gently convex in side view, strongly domed with rounded steep sides in anterior profile. Umbonal and median regions swollen. Fold beginning posterior to midvalve, high, narrow, anteriorly occupied by 6 costae, lateral 2 poorly developed at base of fold. Fold strongly elevated at anterior.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380258: length 11.5, dorsal valve length 10.0, width 12.8, thickness 8.6, apical angle 95°, fold width 5.0, sulcus width 7.2.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): S1787.

TYPES.—Holotype: USNM 380258.

DISCUSSION.—This species is similar to *B. elegantula*, new species, from which it differs in its more narrowly rounded anterolateral extremities, less steep flanks, and much narrower fold.

Burmirhynchia Buckman, 1917

This is a fairly common genus in the late Middle and later Jurassic not only of Burma but of Europe and is well represented in Saudi Arabia. *Burmirhynchia? bicostata*, new species, resembles the typical *Burmirhynchia* in shape and folding. Unfortunately its interior is unknown and its occurrence in the Bajocian of Saudi Arabia is older than that of most burmirhynchias, which range from Bathonian to Callovian.

Ager (1965) reports a strong median septum in *Burmirhynchia*. The Saudi Arabian species and those described by Laurin (1972) have a short, stout septum or ridge tapering anteriorly.

Burmirhynchia angustata, new species

FIGURE 7; PLATE 2: FIGURES 41–49

DIAGNOSIS.—Narrowly elongate oval *Burmirhynchia* with narrow fold and sulcus.

DESCRIPTION.—Medium size, elongate, narrowly oval, dorsal valve more convex than ventral valve, sides rounded, greatest width anterior to midvalve. Apical angle acute. Lateral commissure oblique; anterior commissure narrowly uniplicate. Beak short, suberect to erect; foramen small, hypothyridid; deltidial plates disjunct with marginal rims. Costae numbering 15–17, strong, elevated, subangular.

Ventral valve gently convex in lateral view, medially concave in anterior profile. Umbonal and median regions swollen. Sulcus originating on umbo, deepening anteriorly, depressed below flanks in anterior half. Sulcus occupied by two costae. Tongue short, narrow.

Dorsal valve strongly convex in side view, strongly and narrowly domed in anterior profile, valve swollen, fold with 3 costae originating posterior to midvalve, slightly elevated above convex, steep flanks in anterior half.

Interior: Ventral valve thick-shelled with dental plates covered by shell tissue for about 1/3 valve length; dental plates thick and persisting for 1/3 valve length as seen in section.

Dorsal valve with thick horizontal hinge plates. Septalium short, obscured by shell tissue. Median septum short, thick, extending for about 1/6 valve length, becoming low ridge throughout sections for more than 1/3 valve length. Crural bases not developed; crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380224a	18.0	15.4	14.7	14.8	76	6.2
380224b	16.5	14.3	14.2	13.0	77	7.0
380609	18.9	17.2	15.3	14.1	82	7.3

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): KK9-15.5, -16, -20, -20.5, -21, -22.5.

TYPES.—Holotype: USNM 380224a, Paratypes: USNM 380224b, 380609, 380637, 380669.

DISCUSSION.—This species is close to *Burmirhynchia decorticata*, new species, with which it occurs. It is distinguished from that species by its narrower form and lesser apical

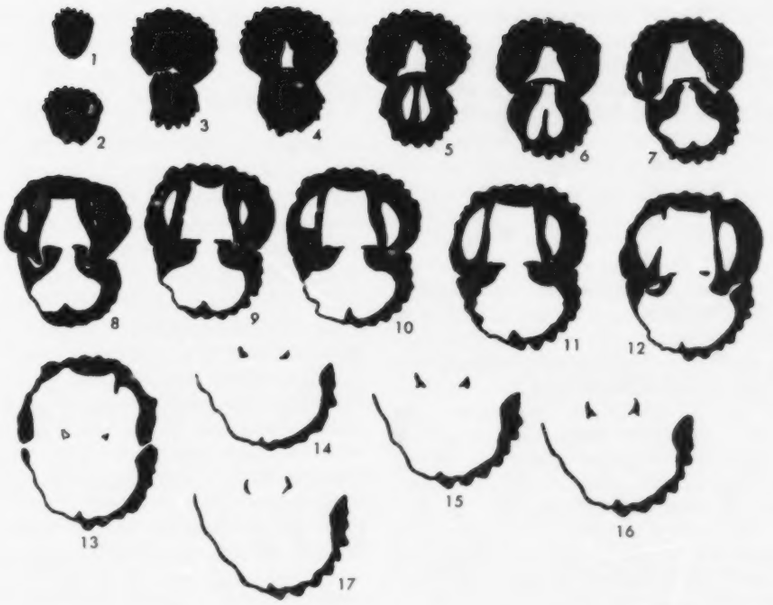


FIGURE 7.—*Burmirhynchia angustata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.3(0.9); 3, 1.3(2.2); 4, 0.8(3.0), 5, 0.3(3.3); 6, 0.2(3.5); 7, 0.4(3.9); 8, 0.3(4.2); 9, 0.3(4.5); 10, 0.2(4.7); 11, 0.3(5.0); 12, 0.2(5.2); 13, 0.3(5.5); 14, 0.5(6.0); 15, 0.2(6.2); 16, 0.2(6.4); 17, 0.4(6.8) Approximately ×2; length 18.3 mm; USNM 380669; Locality KK9-22.5.

angle. It differs from *B.? bicostata*, new species, which also has only two costae in the sulcus, in its larger size, wider beak, and stronger costae.

Burmirhynchia? bicostata, new species

PLATE 2: FIGURES 50–57

DIAGNOSIS.—Small, narrowly oval, two costae in sulcus.

DESCRIPTION.—Small, elongate oval, sides rounded, anterior margin narrowly rounded, somewhat nasute. Apical angle acute. Maximum width anterior to midvalve. Dorsal valve more convex than ventral valve. Lateral commissure nearly straight; anterior commissure uniplicate. Beak short, erect; foramen small, hypothyridid. Deltidial plates thick, disjunct with marginal rims. About 15-16 narrowly rounded costae.

Ventral valve gently convex in side view, flatly convex, with steep sides in anterior profile. Umbonal and median regions swollen. Sulcus shallow, originating at midvalve, depressed below narrow flanks in anterior third. Sulcus occupied by 2 costae. Tongue short.

Dorsal valve moderately convex in side view, narrowly domed with steeply sloping sides in anterior profile. Median region swollen. Fold developing at midvalve, rounded, poorly defined, only slightly elevated above flanks in anterior third. Fold with three costae.

Interior: Ventral with long divergent dental plates as seen through shell.

MEASUREMENTS (in mm).—USNM 380226: length 15.7, dorsal valve length 12.8, width 13.4, thickness 11.6, apical angle 67°, fold width 7.0.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1618.

TYPES.—Holotype: USNM 380226.

DISCUSSION.—See *B. angustata*, new species. This species is doubtfully referred to *Burmirhynchia*, although its exterior agrees in all respects, because its interior is unknown. Its shallow sulcus and low fold are similar to those of typical *Burmirhynchia*.

Burmirhynchia cuneata, new species

PLATE 2: FIGURES 36–40

DIAGNOSIS.—*Burmirhynchia* with subcarinate fold.

DESCRIPTION.—Small, wedge-shaped, triangular, dorsal

valve much deeper than ventral valve. Maximum width at anterior. Anterolateral extremities narrowly rounded, anterior slightly nasute, apical angle acute. Lateral commissure somewhat oblique, anterior commissure strongly, narrowly uniplicate. Beak, low, narrow, incurved. Foramen small, hypothyridid. Deltidial plates concealed. Costae about 18, strong, rounded, separated by striae narrower than costae.

Ventral valve gently convex in lateral view, anterior view broadly sulcate with narrowly rounded steep flanks. Sulcus originating posterior of midvalve, deep and wide in anterior half, occupied by 4 costae. Tongue long, narrow, pointed.

Dorsal valve moderately convex in side view; anterior profile narrowly domed with apex of dome subcarinate. Fold beginning posterior to midvalve, strongly elevated over steep convex flanks in anterior half. Fold with 5 costae, lateral ones subdued.

Interior: Ventral valve with long, divergent dental plates. Dorsal valve with median septum measuring about 1/3 valve length.

MEASUREMENTS (in mm).—USNM 380227: length 16.0, dorsal valve length 13.8, width 14.0, thickness 14.6, apical angle 69°, fold with 7.0.

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1501; (Zone not placed): S1448.

TYPES.—Holotype: USNM 380227.

DISCUSSION.—The narrow form and narrow fold are unlike those of other burmirhynchias described herein.

Burmirhynchia decorticata, new species

PLATE 2: FIGURES 26-35, PLATE 10: FIGURES 13–17, PLATE 18: FIGURES 11–15

DIAGNOSIS.—Medium, with length and width nearly equal.

DESCRIPTION.—Medium, subpentagonal, length and width nearly equal; dorsal valve deeper than ventral valve. Anterior margin truncate; sides rounded, apical angle near or slightly greater than 90°. Lateral commissure straight; anterior commissure strongly uniplicate. Beak short, suberect to incurved; foramen small; deltidial plates disjunct with thickened rims. Costae strong, 14 in number, rounded.

Ventral valve nearly flat in side view, nearly flat with median depression in anterior profile. Umbonal and median regions gently swollen. Sulcus starting in umbonal region, deepening rapidly, moderately depressed below narrowly rounded flanks. Sulcus occupid by 1 or 2 costae, usually 2, and occupying about half valve width.

Dorsal valve with moderate convexity in side view; narrowly domed with precipitious sides in anterior profile. Strongly swollen medially. Fold originating on umbo, moderately elevated above flanks in anterior half. Fold usually with 3 costae.

Interior: Ventral valve with long, diverging dental plates extending half surface length. Dorsal valve with short, low median septum.

MEASUREMENTS.—All measurements in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380257a	17.0	15.0	16.0	13.7?	83	7.3
380383a	18.7	16.0	17.0	13.4	89	7.5
380383b	19.3	16.3	17.1	13.8	90	8.0
380587	17.0	15.0	17.0	13.3?	92	8.2
380588	17.0	15.2	15.7	15.0	86	8.7
380610	18.0	15.8	17.4	15.0?	92	7.9
380649a	20.0	18.1	19.4	17.8	86	10.5
400913	15.7	13.4	14.8	13.6	92	7.6

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1596; (*Tulites* Zone): S1244, S1488; (*Micromphalites* Zone): S1496, S1498. KK9-18-20, -21, -22.5, -51.5, -52, -52.5, -53, -56.5; (*Dhrumaites* Zone): S1275, S1425; (Zone not placed): S457, S1258, S1652. Tuwaiq Mountain Formation: S1476.

TYPES.—Holotype: USNM 380383a. Paratypes: USNM 380257a-c, 380383b-d, 380534a-c, 380587, 380588, 380610, 380649a, 400913, 402741.

DISCUSSION.—Many of the specimens of this species have lost all or part of their shell, hence the name. It is a compact form wider than *B. angustata*, new species, and more strongly costate than that species. It differs from *Pycnoria magna*, new species, in its smaller size, narrower, more triangular form, and less prominent fold and sulcus.

Burmirhynchia rostrata, new species

PLATE 2: FIGURES 13–20

DIAGNOSIS.—*Burmirhynchia* with 5 costae in sulcus and elongate beak.

DESCRIPTION.—About medium, subtriangular, maximum width anterior to midvalve; dorsal valve strongly convex. Apical angle acute. Lateral commissure straight anterior commissure strongly uniplicate. Beak long, narrow, suberect; foramen large; deltidial plates thick, disjunct with marginal rims. Costae narrowly rounded, crowded, numbering about 20.

Ventral valve gently convex in lateral view; flat with median depression in anterior profile. Fold originating slightly posterior to midvalve, shallow, widening anteriorly to form fairly long, narrow tongue; sulcus occupied by 5 costae. Flanks narrow steep.

Dorsal valve strongly convex in lateral view; narrowly domed in anterior view. Strongly swollen medially. Fold starting at about midvalve, low, narrow with 6 costae. Flanks steep.

Interior: Ventral valve interior with dental plates one-third valve surface measure. Dorsal valve interior with septum almost reaching midvalve.

MEASUREMENTS.—All measurements are in millimeters,

except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380212a	17.5	13.0	14.6	12.4	70	7.5
380212b	18.2	14.6	16.4	13.6	70	9.2

OCCURRENCE.—Dhruma Formation (Zone not placed): S1118, S1119. Tuwaiq Mountain Formation (72.7–88.5 m above base): S1674.

TYPE.—Holotype: USNM 380212a. Paratype: USNM 380212b.

DISCUSSION.—This species is characterized by its long beak, differing from all other burmirhynchias described herein in this feature. It differs from the two new species, *B. angustata* and *B. decorticata*, in the greater number of costae in the sulcus. It is larger and more strongly costate than *B.? bicostata*, new species, and with more costae in fold and on sulcus.

Burmirhynchia subnasuta, new species

PLATE 2: FIGURES 21–25

DIAGNOSIS.—*Burmirhynchia* with subnasute anterior.

DESCRIPTION.—About medium, elongate oval, widest anterior to midvalve. Sides rounded, anterior somewhat nasute, apical angle acute. Lateral commissure slightly oblique; anterior commissure uniplicate. Beak short erect; foramen fairly large, hypothyridid; deltidial plates disjunct, thick, with marginal rims. Costae strong, subangular, about 19.

Ventral valve flatly convex in side view; gently concave in anterior profile. Sulcus originating at about midvalve, not sunken below rounded flanks, occupied by 4 costae. Tongue very short.

Dorsal valve slightly more convex than ventral valve in side view; moderately domed in anterior view. Median and umbonal regions swollen. Fold starting at midvalve, slightly elevated above narrow, steep flanks in anterior third. Fold slightly protuberant, with 5 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380225: length 18.4, dorsal valve length 16.0, width 16.4, thickness 12.5, apical angle 84°, fold width 9.7.

OCCURRENCE.—Dhruma Formation (Zone not placed): S1414.

TYPES.—Holotype: USNM 380225.

DISCUSSION.—This species is wider than *B. angustata*, new species, and has more costae in sulcus and on the fold. It is less angular than *B. decorticata*, new species, with more costae in sulcus and nasute rather than with truncate anterior as in *B. decorticata*.

Colpotoria, new genus

TYPE SPECIES.—*Colpotoria plicatilis*, new species.

DIAGNOSIS.—Large, elongate triangular; dorsal valve more convex than ventral valve. Beak narrow, pointed, straight to erect, deltidal plates disjunct to conjunct; foramen small, hypothyridid. Sulcus with anterior fold; fold with anterior sulcus; anterior quadrilobate. Costae numerous, narrow, flattened, crowded, separated by striae narrower than costae. Dental plates long, divergent. Cardinalia thickened; septum long, thick. No cardinal process. Crura radulifer.

SPECIMENS STUDIED.—14.

GEOLOGICAL OCCURRENCE.—Bathonian to Callovian.

ETYMOLOGY.—Greek *kolpotos* (formed into folds).

DISCUSSION.—Inside the ventral valve the dental plates have half disappeared at the plane of articulation, and completely disappear at the point at which the hinge plates no longer are attached to the valve wall. The median septum is present for more than half the valve surface length.

Colpotoria differs from *Conarosia*, new genus, in its strongly triangular form and quadrate anterior as well as the development of its interior. *Colpotoria* resembles *Heteromychus*, new genus, in its quadrate anterior. It differs, however, in the development of the dorsal hinge structures, its narrow elongate triangular form, and lack of a cardinal process.

Colpotoria magna, new species

PLATE 3: FIGURES 43–47

DIAGNOSIS.—Large, elongate *Colpotoria*.

DESCRIPTION.—Large, narrowly triangular, greatest width at anterior. Lateral margins forming acute angle (64°). Anterior margin quadrilobate. Anterior commissure unplicate with sulcate fold and sulcus with median fold. Beak fairly long, suberect, deltidial plates disjunct, rimmed, foramen small, hypothyridid. Surface finely costate, costae flatly rounded, about 26.

Ventral valve gently convex in side view, nearly flat in anterior view with abrupt, steep slopes. Sulcus originating anterior of midvalve, shallow, marked medially by narrow fold. Flanks narrowly rounded.

Dorsal valve gently convex, narrowly and strongly umbonate; anterior view flatly convex, with abrupt slopes. Fold originating anterior to midvalve, marked medially by narrow, deep sulcus.

Interior unknown.

MEASUREMENTS (in mm).—USNM 380452: length 37.4, dorsal valve length 34.7, width 29.5, thickenss 26.7, apical angle 64°, fold width 17.0.

OCCURRENCE.—Dhruma Formation (Zone not placed): S1652.

TYPE.—Holotype: USNM 380452.

DISCUSSION.—This species is readily separated from *Colpo-*

toria plicatilis, new species, by its larger size, narrow form, and strong anterior plication. This species differs from specimens of *Heteromychus*, new genus, in its narrow, sharp suberect beak and elongate triangular form with strong anterior quadriplication.

Colpotoria plicatilis, new species

FIGURE 8; PLATE 3: FIGURES 27–42, PLATE 18: FIGURES 16–20

DIAGNOSIS.—Large, triangular rhynchonellid with quadriplicate anterior.

DESCRIPTION.—Large, elongate triangular; subequally biconvex; maximum width at anterior. Anterolateral extremities narrowly rounded, lateral margins nearly straight, forming an acute angle of 56° to 86°; anterior margin truncate, with 4 anterior lobes. Lateral commissure straight; anterior commissure uniplicate with modified fold and sulcus, fold marked by median sulcus, sulcus with median fold. Beak short, narrow, pointed, straight to incurved; foramen small; deltidial plates conjunct with strong marginal rims. Surface finely costate, costae numerous, flattened, crowded, separated by striae narrower than costae.

Ventral valve gently convex in side view; broadly, flatly convex in anterior profile. Umbonal and median regions gently swollen. Sulcus originating at midvalve, broad, shallow with median narrow low fold in anterior third or half. Flanks bounding sulcus narrow, steep. Sulcus with 7–14 costae.

FIGURE 8.—*Colpotoria plicatilis*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.9(0.9); 2, 0.1.2(2.1); 3, 0.6(2.7); 4, 0.3(3.0); 5, 0.2(3.2); 6, 0.8(4.0); 7, 0.7(4.7); 8, 0.3(5.0); 9, 0.4(5.4); 10, 0.2(5.6); 11, 0.4(6.0); 12, 0.4(6.4); 13, 0.3(6.7); 14, 0.3(7.0); 15, 0.3(7.3); 16, 0.4(7.7); 17, 0.4(8.1). Dorsal septum disappears at 15.1 mm from beak; approximately ×1.5; length 22.7; USNM 380654; Locality S1151. 18, section at the plane of articulation of specimen USNM 380208f showing thick shell and thick median septum, approximately ×3; Locality S1151.

Dorsal valve more convex than ventral valve, moderately convex in side view; roundly domed in anterior view. Umbonal region inflated. Fold low, originating somewhat anterior of midvalve, marked medially by narrow, fairly deep sulcus giving bilobed aspect to fold and quadrilobate appearance to anterior. Flanks bounding fold gently depressed in anterior third. Fold with 8–15 costae. Flanks steep.

Interior: Ventral valve with long, divergent dental plates reaching about 1/3 valve surface length, almost disappearing at plane of articulation.

Dorsal valve with long thick median septum extending well beyond midvalve; cardinalia thickened. Crural bases not developed, crura radalifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380208a	25.6	22.4	26.0	19.0	86	15.0
380208b	26.0	23.2	24.0	19.4	67	13.7
380208e	21.4	18.2	18.0	16.5	65	10.0
380599a	26.0	23.3	24.6	20.4	78	14.0
380600	25.0	21.9	23.2	18.2	81	14.0
380611a	25.4	22.6	22.0	19.5	82	13.7
380612	24.4	21.4	23.0	18.3	70	11.5

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1503; (*Micromphalites* Zone): S743. S1151; (*Dhrumaites* Zone): S1200, S1508; (Zone not placed): S1612.

TYPES.—Holotype: USNM 380208a. Paratypes: USNM 380208b–f, 380599a,b, 380600, 380611a,b, 380612, 380654, 380692.

DISCUSSION.—The triangular form and quadrilobate anterior of this species is unlike that of any other rhynchonellid except *Heteromychus*. The ornamentation of *Colpotoria* suggests that of *Conarosia*. That genus however, tends to a rotund form rather than triangular and has a different interior. The same is true of *Heteromychus* which, unlike *Colpotoria*, has a large cardinal process in the dorsal valve.

Rhynchonella cf. *budulcaensis* Stefanini as figured by Dubar (1967, pl. 1: figs. 9a,b) is suggestive of *Colpotoria* in its elongate triangular form but appears not to be quadrilobate anteriorly.

Conarosia, new genus

TYPE SPECIES.—*Conarosia rotundata*, new species.

DIAGNOSIS.—Often large, strongly biconvex, uniplicate rhynchonellids with long dental plates, small septalium, small foramen and long median septum.

DESCRIPTION.—Large, narrowly, roundly oval in outline, strongly rounded in side view; dorsal valve usually deeper, more convex than ventral valve. Beak strongly incurved, almost touching umbo of dorsal valve. Deltidial plates thick, short, conjunct. Foramen small to minute, usually concealed; hypothyridid. Anterior commissure uniplicate forming indistinct, narrow to wide fold and sulcus. Surface costate, costae narrow, rounded to flattened, separated by striae narrower than costae.

Interior: Ventral valve with short, tubular pedicle collar. Dental plates diverging narrowly, strong, thin, elevated, long, bounding narrow delthyrial cavity.

Dorsal valve interior with short, narrow septalium, long high median septum; crura curved, moderately long, widening distally, of radulifer type.

GEOLOGICAL OCCURRENCE.—Lias (Toarcian) to Bathonian.

ETYMOLOGY.—Greek *konaros* (well fed).

DISCUSSION.—This genus is most like *Heteromychus* in external appearance but never shows any tendency to develop a quadrate anterior or a cardinal process. Internally it has a narrower, deeper cruralium than *Heteromychus* and has not developed a cardinal process like *Heteromychus*. It is possible that *Heteromychus* is a direct descendant of *Conarosia*. From other large Saudi Arabian rhynchonellids *Conarosia* differs in its rounded, compact form and fine costae. It differs from *Colpotoria*, new genus, in its rounded ventral umbo and rotund form rather than triangular like *Colpotoria*. The latter is quadrilobate anteriorly which is unlike the moderate uniplication of *Conarosia*.

The earliest representative of *Conarosia* is a single specimen from the Marrat Formation. Although the interior of this specimen is unknown, the exterior is exactly like that of typical *Conarosia*. It is next seen in the *Ermoceras* Zone of the Dhruma Formation and ranges upward into the *Dhrumaites* Zone. It is an excellent guide fossil to the Dhruma Formation.

Conarosia angustata, new species

PLATE 3: FIGURES 22–26

DIAGNOSIS.—Narrow elongate *Conarosia*.

DESCRIPTION.—Medium, narrowly elongate oval, length about 1.5 times width. Dorsal valve more convex than ventral valve; anterior narrowly rounded, sides gently rounded; apical angle acute. Lateral commissure straight; anterior commissure uniplicate. Beak short, incurved; foramen small; deltidial plates conjunct. Costae rounded, about 30.

Ventral valve moderately convex in side view with maximum convexity in umbonal region. Anterior profile forming low steep-sided dome. Sulcus defined at anterior commissure, marked by six costae. Tongue short.

Dorsal valve nearly hemispherical in side view; strongly, narrowly domed in anterior profile. Fold poorly defined, seen best at anterior commissure, with 7 costae.

Interior: Dorsal valve with long median septum reaching to midvalve.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees. Questionmark

indicates that measurement is taken from a broken specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380580	20.7	18.0	16.0	18.2	57	7.7
380581	21.7	18.8	15.6?	18.0	58	8.2
380649	22.8	19.6	16.2	20.1	58	10.0

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1501, KK8-33–35.5; (*Tulites* Zone): S1488; (*Micromphalites* Zone): KK9-9–KK9-72; (Zone not placed): S1418, S1457.

TYPES.—Holotype: USNM 380649. Paratypes: USNM 380580, 380581.

DISCUSSION.—The smallest and narrowest of *Conarosia* species.

Conarosia concinna, new species

FIGURE 9; PLATE 3: FIGURES 1–16

DIAGNOSIS.—Roundly, widely oval *Conarosia*.

DESCRIPTION.—Large, but small for genus, compactly, roundly oval, dorsal valve more convex than ventral valve; sides and anterior rounded; apical angle acute. Lateral commissure straight; anterior commissure strongly uniplicate. Beak, low, rounded, apical angle acute. Lateral commissure straight; anterior commissure strongly uniplicate. Beak, low, rounded, incurved close to dorsal umbo; foramen small. Deltidial plates thick. Costae flatly rounded, crowded, separated by striae narrower than costae, about 30–40 in number.

Ventral valve moderately convex with greatest curvature at umbo in side view. Anterior view gently domed, with steep sides. Valve evenly swollen. Sulcus barely precepüble except in anterior half. Sulcus occupied by 8 or 9 costae. Tongue long, rounded at extremity.

Dorsal valve hemispherical in side view, strongly domed with steep sides in anterior profile. Valve greatly swollen. Fold discernible only at anterior commissure, occupied by 9 or 10 costae.

Interior as for genus.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380213	24.7	21.6	19.6	22.0	69	10.0
380460	19.8	17.5	16.8	17.0	80	7.6
380461	20.7	18.0	16.9	18.0	73	9.4
380584	25.4	22.0	20.5	22.0	72	10.0
380585a	24.4	21.4	19.3	22.0	81	10.0

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1046, S1160, S1482, S1501, KK8-17.5, -21, -32; (*Tulites* Zone): S1422, S1488; KK8-39.5; (Zone not placed): S1447, S1450, S1456, S1457, S1688, S1743.

TYPES.—Holotype: USNM 380213. Paratypes: USNM 380294, 380460, 380461, 380584, 380585a,b, 400912.

DISCUSSION.—In size and general appearance this species is similar to *Conarosia medialis*, new species. It differs in having a more evenly convex dorsal valve in side view and a more strongly curved umbo of the ventral valve. It differs from *C. matutina*, new species, in having greater convexity and a wider fold and sulcus.

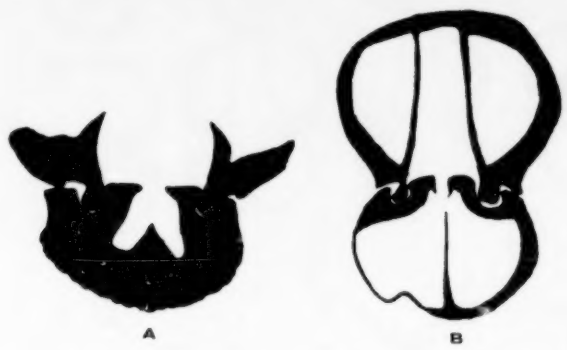


FIGURE 9.—*Conarosia concinna*, new species: Sections through the plane of symmetry of (A) USNM 380294, showing greatly thickened shell, ×3, Locality S1160, and (B) USNM 400912, ×3, Locality S1447.

Conarosia matutina, new species

PLATE 3: FIGURES 17–21

DIAGNOSIS.—*Conarosia* with narrow fold and sulcus.

DESCRIPTION.—Large, elongate oval, dorsal valve more convex than ventral valve; maximum width slightly anterior to midvalve. Anterior narrowly rounded, sides rounded, apical angle acute, lateral commissure straight; anterior commissure narrowly uniplicate. Beak low, rounded; foramen, small, hypothyridid. Deltidial plates conjunct, anteriorly thickened. Costae crowded, numbering about 33.

Ventral valve evenly convex in side view with maximum convexity in umbonal region; anterior view broadly domed with steep sides. Sulcus starting at midvalve, very shallow, inconspicuous, forming short, narrowly rounded tongue. Sulcus with six costae.

Dorsal valve fairly evenly and strongly convex in side view, strongly domed in anterior profile. Fold low, barely distinguishable at anterior third. Fold with 7 costae.

Interior: Ventral valve with long subparallel dental plates about 1.5 mm apart at half length of dental plates. Other details of interior not seen.

MEASUREMENTS (in mm).—USNM 380276: length 25.4, dorsal valve length 22.0, width 21.6, thickness 20.7, apical angle 80°?, fold width 8.0.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): KK6-14.

TYPES.—Holotype: USNM 380276.

DISCUSSION.—This, the earliest species of the genus, is similar to *Conarosia ovata*, *C. medialis*, and *C. concinna*, all new species. It differs from the first in its lesser convexity, narrower ventral tongue and fewer costae in the sulcus. It differs from both *C. medialis* and *C. concinna* in having less convexity and much narrower dorsal fold and sulcus. The great gap in the occurrence of *C. matutina* between the *Bouleiceras* Zone of the Lias and the *Ermoceras* Zone of the Bajocian suggests the possibility that this is a float specimen.

Conarosia medialis, new species

FIGURES 10, 11; PLATE 6: FIGURES 20–29

DIAGNOSIS.—*Conarosia* with narrow form and swollen dorsal valve posterior. Sulcus well marked at anterior.

DESCRIPTION.—Large, elongate oval, dorsal valve much more convex than ventral valve. Maximum width at anterior. Anterior margin gently rounded, sides nearly straight, apical angle acute. Lateral commissure straight; anterior commissure strongly, broadly uniplicate. Beak low, rounded, strongly incurved, almost touching dorsal umbo. Foramen small, hypothyridid. Deltidial plates thick, conjunct. Finely costate, costae narrowly rounded separated by striae narrower than costae. About 40 costae.

Ventral valve moderately convex in side view with most convexity to umbonal region. Anterior profile broadly, gently convex with steep sides. Umbonal and median regions swollen. Sulcus originating at about midvalve, shallow, gently depressed below flanks in anterior third. Sulcus with 7–9 costae. Tongue short, broadly rounded.

Dorsal valve strongly convex in side view with most convexity in posterior; anterior profile forming a convex, steep-sided dome. Dorsal valve greatly swollen in posterior and median regions. Fold poorly defined, very slightly elevated at the anterior. Sulcus with 7–9 costae.

Interior: Ventral valve with narrowly spaced dental plates thickened, convergent ventrally; delthyrial chamber narrow ventrally. Dental plates disappearing in section about 6 mm from beak.

Dorsal valve with small septalium; median septum long reaching nearly to midvalve. Crural bases not developed, crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380214	27.3	24.5	21.5	25.0	62	12.5
380278a	24.6	22.0	21.3	21.4	63	10.4
380361	27.2	23.5	22.0	24.5	73	10.3
380583a	25.0	23.3	21.5	21.9	60	11.6
380583b	24.0	21.8	20.5	21.0	72	11.4

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): KK7-130.5–KK7-133; (*Thambites* Zone): S1036, S1046, S1157, S1160, S1482, S1501. KK8-23, -33-35, -30-35, -35-38, -35-40; KK8a-34, KK8b-20-35; (*Tulites* Zone): KK8-39.5; (*Micromphalites* Zone): KK9-10-20, -30-35, -30-40; (*Dhrumaites* Zone): S1436. (Zone not placed): S1119, S1158, S1447, S1688, S1743, S1789, S1790.

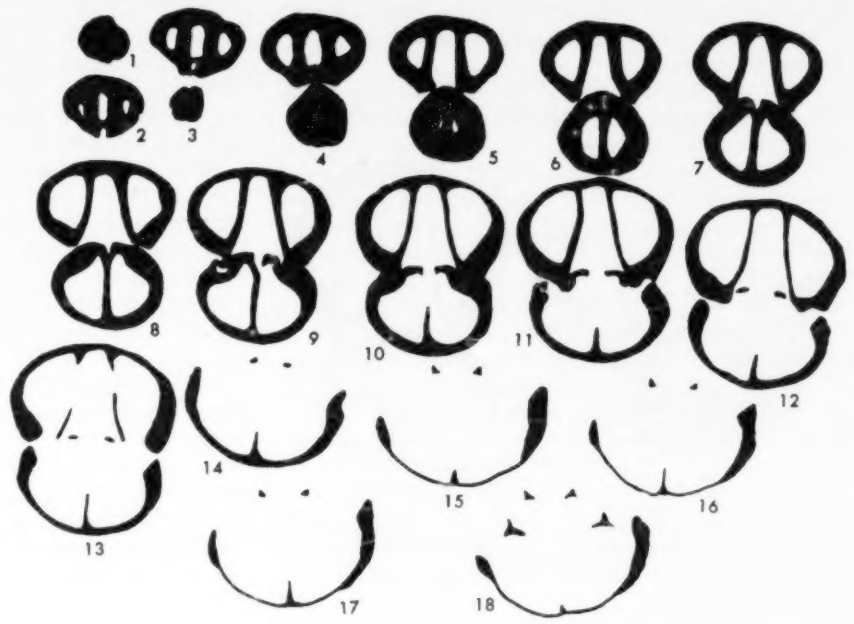


FIGURE 10.—*Conarosia medialis*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.7(1.3); 3, 0.5(1.8); 4, 0.3(2.1); 5, 0.3(2.4); 6, 0.3(2.7); 7, 0.3(3.0), 8, 0.3(3.3), 9, 0.2(3.5); 10, 0.2(3.7); 11, 0.3(4.0); 12, 0.3(4.3); 13, 0.2(4.5); 14, 0.5(5.0); 15, 0.2(5.2); 16, 0.3(5.5); 17, 0.2(5.7); 18, 0.3(6.0). Approximately ×2; length 21.5 mm; USNM 380660; Locality S1447.

TYPES.—Holotype: USNM 380278a. Paratypes: USNM 380214, 380278b,c, 380361, 380583a,b, 380660.

DISCUSSION.—This is a fairly common species characterized by its narrow form, medium size for the genus, dorsal valve strongly swollen posteriorly and with a distinct sulcus. It differs from the new species, *C. concinna*, *C. ovata*, and *C. matutina*, which it resembles, in the named features.

Conarosia ovata, new species

PLATE 6: FIGURES 30–44

DIAGNOSIS.—Similar to *C. concinna*, new species, but larger and with stronger costae.

DESCRIPTION.—Large, elongate oval, maximum width anterior to midvalve. Dorsal valve more convex than ventral valve. Anterior narrowly rounded, sides rounded, apical angle acute. Lateral commissure straight; anterior commissure strongly uniplicate. Beak low, rounded, incurved close to dorsal umbo. Deltidial plates thick, conjunct. Costae rounded, about 33 in number.

Ventral valve moderately convex in side view, gently domed with steep sides in anterior profile. Sulcus perceptible only in anterior third, occupied by 7-9 costae. Tongue fairly long, broadly rounded.

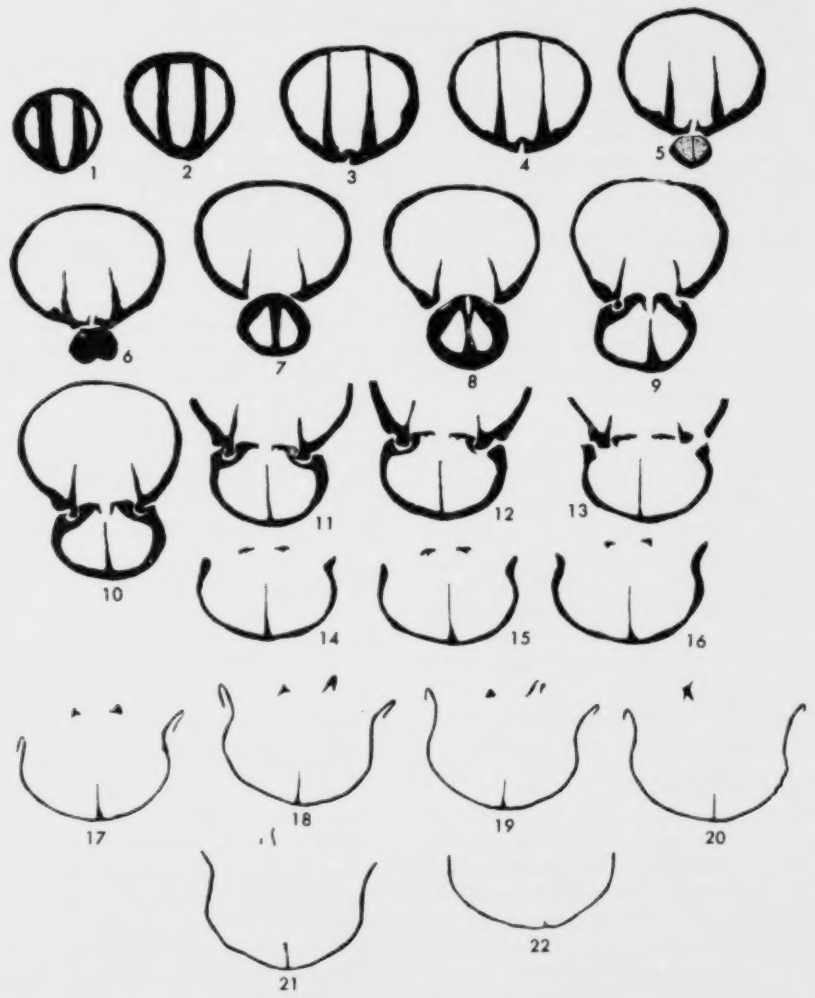


FIGURE 11.—*Conarosia medialis*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.8(0.8); 2, 1.5(2.3); 3, 0.7(3.0); 4, 0.4(3.4); 5, 0.5(3.9); 6, 0.2(4.1); 7, 0.4(4.5); 8, 0.2(4.7); 9, 0.3(5.0); 10, 0.3(5.3); 11, 0.2(5.5); 12, 0.3(5.8); 13, 0.4(6.2); 14, 0.4(6.6); 15, 0.2(6.8); 16, 0.3(7.1); 17, 0.5(7.6); 18 0.2(7.8); 19, 0.1(7.9); 20, 0.4(8.3); 21, 0.4(8.7); 22, 0.9(9.6). Approximately ×1.7; length 25.5 mm; USNM 380278c; Locality S1482.

Dorsal valve strongly and evenly convex in side view, strongly, narrowly domed in anterior view. Median region greatly swollen from umbo to front margin. Fold beginning just anterior to midvalve, poorly defined except at commissure with 8-10 costae.

Interior: Ventral valve with apically thickened, long, divergent dental plates extending about 1/3 valve surface length.

Dorsal valve interior apically thickened by shell deposit; median septum long, extending to about midvalve.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380280	27.3	24.0	22.7	23.4	79	12.5
380361	26.7	23.5	22.0	24.6	75	13.3
380459	30.0	37.3	23.7	24.6	76	13.6
380613	29.1	25.5	25.0	24.6	100	12.0
400914	39.0	32.0	29.8	33.5	77	15.5

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1167; (*Thambites* Zone): S1045, S1046, S1157, S1160, S1482; KK8-22; -23, -27.7, -35-38, -35.5, -37, KK8a-27; (*Tulites* Zone): KK8-40.5; (*Micromphalites* Zone): KK9-30-40; (Zone not placed): S1119, S1457, S1688, S1788.

TYPES.—Holotype USNM 380459. Paratypes: USNM 380280, 380361, 380582a,b, 380586, 380613, 400914.

DISCUSSION.—This species is larger than *C. concinna*, new species, and *C. medialis*, new species, with stronger costation and with divergent dental plates as seen on exterior, a difference from *C. medialis*. It is more oval than *C. rotunda*, new species, which is ball-like. It is not as large as *C. sphenoidea*, new species, and is differently proportioned. *Conarosia ovata* is suggestive of *Xenorina ovata*, new species, a zeilleriid, being distinguished by its anterior fold. *Xenorina* is rectimarginate.

Conarosia rotundata, new species

FIGURE 12; PLATE 4: FIGURES 10–31

DIAGNOSIS.—Large almost spherical *Conarosia*.

DESCRIPTION.—Large, subspherical, unequally convex, dorsal valve with greater convexity than ventral valve; maximum width anterior to midvalve. Sides rounded; anterior margin somewhat nasute. Apical angle variable. Lateral commissure straight; anterior commissure strongly uniplicate. Beak low, incurved, lying close to dorsal umbo; foramen small, hypothyridid; deltidial plates conjunct, thickened, elevated anteriorly. Costae narrowly rounded, up to 48 in number.

Ventral valve fairly strongly convex with most convexity at umbo in side view; moderately domed with steep sides in anterior profile. Valve swollen medially. Sulcus starting at midvalve, shallow, slightly depressed below flanks in anterior half. Sulcus with 9-11 costae. Tongue moderately long.

Dorsal valve almost hemispherical in side view; strongly domed in anterior view. Valve greatly swollen. Fold starting at midvalve, moderately elevated throughout its extent, forming, with ventral tongue, moderate protuberance. Fold with 10-12 costae. Flanks steep, rounded.

Interior: Ventral valve with thickened apex; dental plates long, slightly divergent, fairly closely spaced in large specimens.

Dorsal valve interior with narrow septalium, long median septum reaching midvalve and radulifer crura.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates uncertain data.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380287a	37.8	32.0	33.0	34.6	89	18.0
380287b	25.8	23.2	24.6	20.0	107	12.6
380360a	30.0	27.0	29.7	24.0	95	13.0
380579a	29.0	25.6	27.6	23.0	84	12.3
380579b	26.5	23.7	24.6	23.8	?	13.0

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): KK8-5.5; (*Thambites* Zone): S1036, S1044, S1501, S1503, KK8b-20–35, KK8-23. (*Micromphalites* Zone): KK9-30–40; (Zone not placed): S1743.

TYPES.—Holotype: USNM 380287a. Paratypes: USNM 380287b,c, 380360a,b, 380379, 380579a,b, 380663.

DISCUSSION.—This is one of three very large species of *Conarosia* and among the largest of rhynchonellida. It is distinguished from *C. sphenoidea*, new species, by its strongly rotund form and the more prominent development of fold and sulcus in late adulthood.

Conarosia sphenoidea, new species

PLATE 5: FIGURES 1–25

DIAGNOSIS.—Triangular to subtriangular, large *Conarosia* with subdued fold and sulcus.

DESCRIPTION.—Large, subtriangular to subpentagonal, maximum width anterior to midvalve. Dorsal valve deeper than ventral valve. Anterolateral extremities rounded, anterior margin gently rounded; apical angle variable, near a right angle. Lateral commissure straight; anterior commissure strongly uniplicate. Beak low, erect to incurved. Foramen small, hypothyridid; deltidial plates thick, disjunct to conjunct. Costae narrowly rounded, crowded, about 40.

Ventral valve gently convex in side view, most convex in umbonal region. Anterior profile broadly, flatly convex. Sulcus originating about midvalve, slightly depressed below flanks anteriorly, occupied by 9-11 costae. Tongue short. Flanks rounded, steep.

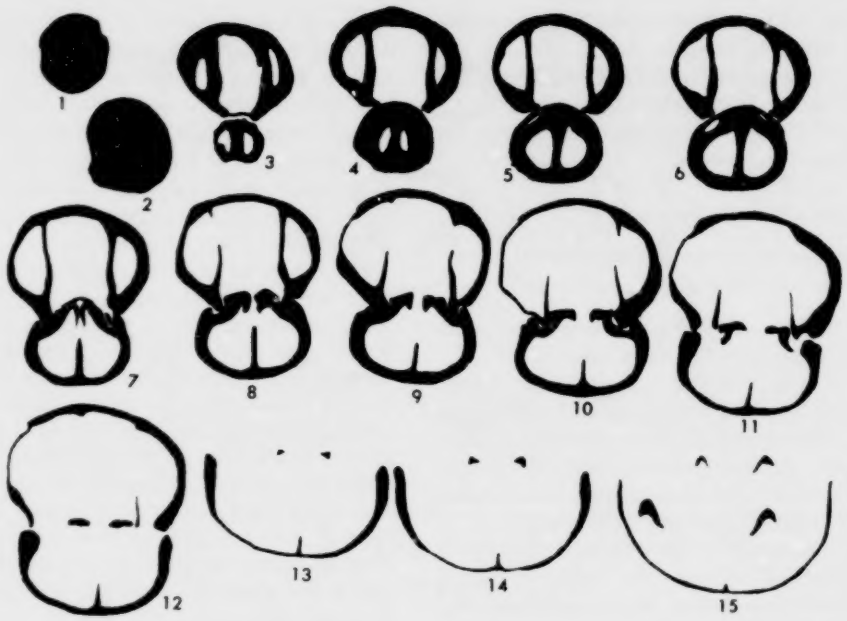


FIGURE 12.—*Conarosia rotundata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.8(0.8); 2, 0.5(1.3); 3, 1.1(2.4); 4, 0.6(3.0); 5, 0.2(3.2); 6, 0.2(3 4); 7, 0.3(3.7); 8, 0.3(4.0); 9, 0.3(4.3); 10, 0.2(4.5); 11, 0.2(4.7); 12, 0.3(5.0); 13, 1.1(6.1); 14, 0.4(6.5); 15, 1.1(7.6). Septum disappears at 7.9 mm. Approximately ×2; length 25.4 mm; USNM 380663; Locality KK8-5.

Dorsal valve moderately convex in side view with most convexity at umbo. Anterior profile forming high dome with steep, convex slopes. Umbonal and median regions swollen. Fold barely perceptible, best seen at anterior. Fold with 10-12 costae.

Interior: Ventral valve with long narrowly divergent dental plates reaching 1/4 valve length.

Dorsal valve with long, narrow septalium; median septum reaching midvalve or beyond.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates that specimen was incomplete or damaged, so that distance could not be measured.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380210	24.6	22.3	24.6	18.6	88	13.5
380219a	36.4	32.8	32.5	26.7	92	15.5
380219b	32.0	28.0	28.0	23.0?	86	16.0
380451	32.9	29.6	27.6	27.0	86	15.9
380577c	26.7	24.0	23.7	20.0	70	13.0
380578	40.3	35.5	34.0	31.4?	74	19.3

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1045, S1501, S1503, S1505, S1620, KK7-134–KK7-138, KK8-9, -10-20, -27, KK8a-27, KK8b-20–35.

TYPES.—Holotype: USNM 380219b. Paratypes: USNM 380210, 380219a,c,d, 380374a,b, 380451, 380577a–c, 380578.

DISCUSSION.—This species is similar to *C. rotundata*, new species, differing however in more triangular form, less convex ventral valve and less development of the fold and sulcus. *Conarosia sphenoidea* is wider and with somewhat less convex valves than *C. ovata*, new species. It differs in exterior details from *Heteromychus*, new genus, in having a simple fold and sulcus without quadrilobation.

Conarosia species

PLATE 4: FIGURES 1–4

DESCRIPTION.—A second large species represented by a single imperfect specimen is characterized by its fine costae. The specimen is rotund with length greater than the width. The almost hemispherical dorsal valve is more convex than the ventral valve. The anterior commissure is strongly uniplicate but the sulcus is defined only at the anterior and is occupied by at least 14 costae, The fold is not preserved. The beak is low and pressed against the dorsal umbo. Two long, narrowly divergent dental plates are visible as is the long median septum.

MEASUREMENTS (in mm).—USNM 380382: length 32.3,

dorsal valve length 28.4, width 27.0 (uncertain), thickness 28.2, apical angle 87°, fold width uncertain.

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1001.

SPECIMEN EXAMINED.—USNM 380382.

DISCUSSION.—This species is more finely costate than any other *Conarosia* noted herein.

Cymatorhynchia, Buckman, 1917

Cymatorhynchia? singularis, new species

PLATE 4: FIGURES 5–9, PLATE 18: FIGURES 21–25

DIAGNOSIS.—Medium size for genus, length and width nearly equal, with strongly swollen dorsal valve.

DESCRIPTION.—Large, rounded subpentagonal, length-width nearly equal. Sides and anterior rounded; apical angle slightly obtuse. Maximum width near midvalve. Anterior commissure strongly, arcuately uniplicate. Beak short, narrow. Foramen large; deltidial plates thick, disjunct, elevated anteriorly. Costae strong, subangular, distant, about 20–23.

Ventral valve flatly convex in side view, broadly sulcate in anterior profile. Umbonal region swollen. Sulcus originating just posterior of midvalve, shallow, broad, gently depressed in anterior half, with 5 or 6 costae. Flanks narrow, convex.

Dorsal valve moderately convex in side view, strongly, broadly domed in anterior profile. Valve swollen. Fold originating posterior of midvalve, low, rounded, gently elevated above steep, rounded flanks, with 6 or 7 costae.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380517a	28.2	24.7	27.6	20.0	92	16.6
380517b	29.0	26.8	29.3	22.4	94	16.4
380614	29.0	25.6	28.7	19.6	94	17.3

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1485, S1506.

TYPES.—Holotype: USNM 380517a. Paratypes: USNM 380517b,c, 380614.

DISCUSSION.—This species differs from *Cymatorhynchia cymatophorina* as figured by Buckman (1917, pl. 17: fig. 15a,c) in being less wide and with stronger costation. This species also resembles *C. quadriplicata* (Zieten) as figured by Arcelin and Roché (1936, pl. 3: fig. 3a–c), differing in having a more elongated, narrower beak, more strongly swollen dorsal valve, greater thickness, and lesser apical angle.

Daghanirhynchia Muir-Wood, 1935

Daghanirhynchia Muir-Wood, 1935:82.

DISCUSSION.—The specimens considered here conform in every way with the external details of *Daghanirhynchia*, but this is not true of the interior details, because none of the Saudi Arabian specimens have the accessory plate uniting the horizontal hinge plates seen in Muir-Wood's serial sections. She states that this plate appears in adult specimens, gives no serial sections for young specimens nor for the other species of *Daghanirhynchia* described. It is stated, however, that all species except *D. subversibilis* Weir (1925) have internal structure like that of the type species.

It is not known what the function of this accessory plate might have been, perhaps an additional surface for expansion of pedicle muscles. None of the Saudi Arabian species shows this horizontal plate although many specimens were sectioned. Inasmuch as this is an adult phenomenon it may be related to ecological conditions in the Jurassic sea covering parts of the Somali Republic,conditions that did not obtain in the Jurassic sea over Saudi Arabia. Considering the possibility that this feature may be a local phenomenon, the specimens conforming to *Daghanirhynchia* in all other respects, are placed in that genus. I was not able to identify the type species of *Daghanirhynchia daghaniensis* Muir-Wood in Saudi Arabia, a name that appears in some specimen lists in stratigraphic discussions (Powers et al., 1966:D47).

Dubar (1967:38–41) describes *Somalirhynchia* from Tunisia but did not recognize *Daghanirhynchia* there. His species *Rhynchonella tazerdunensis* and *R. djeffarae*, according to their serial sections are in close accordance with the sections of *Daghanirhynchia angulocostata*, new species, herein (Figure 14), and probably should be referred to *Daghanirhynchia*.

Daghanirhynchia angulocostata, new species

FIGURES 13, 14; PLATE 6: FIGURES 1–19, PLATE 7: FIGURES 44–53, PLATE 11: FIGURES 16–21

Rhynchonella orbignyi.—Douvillé, 1916:65, pl. 7: figs. 20–24 [not *Rhynchonella orbignyi* Oppel, 1857].

DIAGNOSIS.—Large, widely triangular *Daghanirhynchia*.

DESCRIPTION.—Large, widely triangular, with maximum width anterior to midvalve. Anterolateral extremities narrowly rounded; anterior margin broadly rounded; apical angle variable. Anterior commissure strongly uniplicate. Beak narrow, suberect; foramen large longitudinally oval; deltidial plates conjunct or disjunct with marginal rims. Costae strong, subangular, 14 to 16 in number.

Ventral valve nearly flat in lateral view, broadly sulcate in anterior profile. Umbonal region gently swollen. Sulcus originating slightly posterior of midvalve, deepening rapidly to anterior margin, with 3 to 5 costae. Tongue moderately long. Flanks bounding sulcus narrow, flat to gently convex.

Dorsal valve fairly strongly convex in side view, strongly, broadly domed in anterior view. Median region swollen. Fold originating slightly posterior to midvalve, elevating moderately, slowly widening the anterior margin, with 4 to 6 costae.

Interior: Dorsal valve with small septalium; median septum

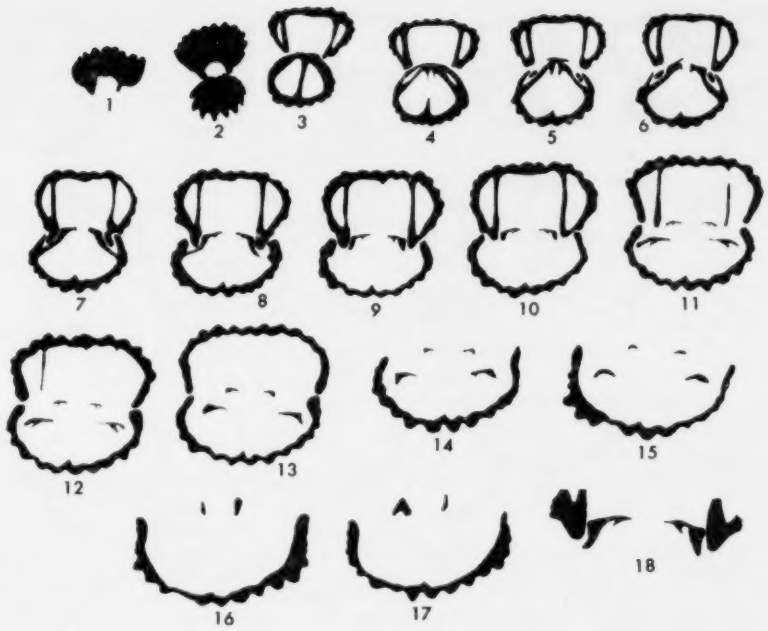


FIGURE 13.—*Daghanirhynchia angulocostata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 1.5(1.5); 2, 0.3(1.8); 3, 0.4(2.2); 4, 0.1(2.3); 5, 0.3(2.6); 6, 0.2(2.8); 7, 0.2(3.0); 8, 0.3(3.3); 9, 0.3(3.6); 10, 0.1(3.7); 11, 0.3(4.0); 12, 0.1(4.1); 13, 0.3(4.4); 14, 0.2(4.6); 15, 0.3(4.9); 16, 0.3(5.2); 17, 0.2(5.4). Approximately ×2; 18, detail of cardinalia of section 10, approximately ×4; length 18.0 mm; USNM 402734; Locality S1275.

extending for about 1/3 valve length.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380201a	25.0	22.3	29.0	19.6	90	14.5
380201b	22.3	19.4	24.5	14.2	92	13.0
380440a	26.5	23.0	28.5	16.6	90	15.8
380441	25.2	22.6	26.0	16.0	92	13.0
380498a	19.6	18.0	21.5	14.4	95	9.5
380520	18.2	16.5	22.0	15.4	102	11.4

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): KK8-25; (*Tulites* Zone): S1191, S1305, S1684; (*Micromphalites* Zone): S743, S1496, S1498, S1500, KK9-22.5, -54; (*Dhrumaites* Zone): S1007, S1275, S1765; (Atash Member): KK9-120, -123; (Hisyan Member): S1445, S1463, S1724; (Zone not placed): S1004, S1118, S1119, S1120; S1179, S1251, S1274, S1613, S1644, S1652, S1786. Upper Dhruma Formation (Zone not placed): S1257, S1311. Tuwaiq Mountain Formation: S1365, S1784.

TYPES.—Holotype: 380201a. Paratypes: 380201b, 380220, 380440a–c, 380441, 380443, 380498a-c, 380520, 380566, 380605a,b, 380606a,b, 380607, 380615, 380616, 380672, 402734.

DISCUSSION.—The specimens described here agree in shell dimensions and general appearance with the holotype of *Daghanirhynchia daghaniensis* Muir-Wood (1935:83). In detail they differ in having more costae on fold and sulcus and less numerous costae. The dimensions of the specimen (USNM 380440a) has length and width measurements almost the same as Muir-Wood's holotype. The fine radial striae mentioned by Muir-Wood as a feature of this genus were not seen on any of the specimens from Saudi Arabia, nor on the few specimens in the USNM collections from the type locality of *D. daghaniensis* Muir-Wood (USNM 75665, 75666).

Large specimens of *D. angulocostata* are suggestive of *Rhynchonella* [= *Daghanirhynchia*?] *huddlestoni* Rollier as figured by Stefanini (1925). They differ from Stefanini's specimens in being wider with distant sharper ribbing and greater thickness. From *Rhynchonella* [= *Daghanirhynchia*?] *hadramautensis* Stefanini, *D. angulocostata* differs in being wider, with more elevated costae and with less costae in the sulcus. Both species figured by Stefanini strongly resemble the African *Daghanirhynchia*.

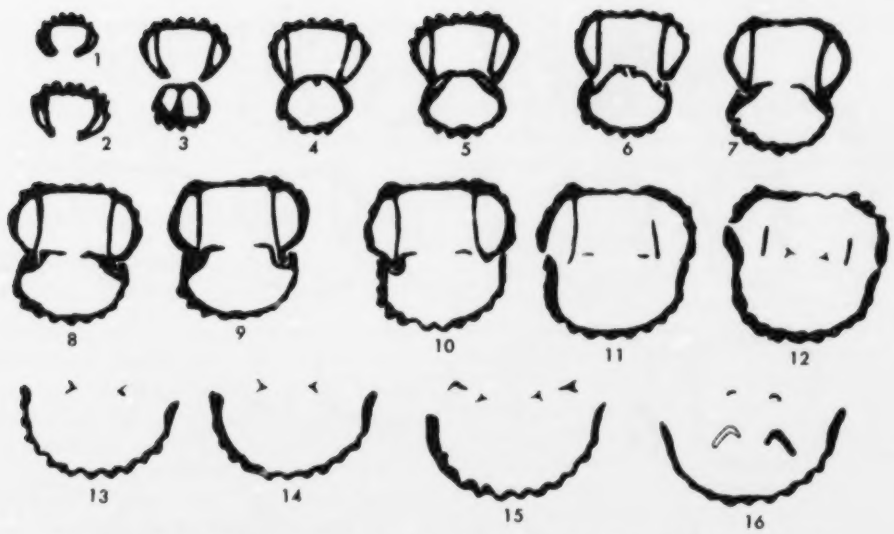


FIGURE 14.—*Daghanirhynchia angulocostata*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 1.0(1.0); 2, 0.5(1.5); 3, 0.3(1.8); 4, 0.3(2.1); 5, 0.4(2.5); 6, 0.2(2.7); 7, 0.2(2.9); 8, 0.2(3.1); 9, 0.3(3.4); 10, 0.2(3.6); 11, 0.2(3.8); 12, 0.3(4.1); 13, 0.1(4.2); 14, 0.2(4.4); 15, 0.2(4.6); 16, 0.1(4.7). Approximately ×2; length 14.1 mm; USNM 380672; Locality S1644.

Daghanirhynchia sulcata, new species

PLATE 5: FIGURES 29–38, PLATE 7: FIGURES 1–5

DIAGNOSIS.—Large *Daghanirhynchia* with numerous costae.

DESCRIPTION.—Large, triangular, wider than long, maximum width anterior to midvalve. Anterior margin broadly rounded, anterolateral extremities narrowly rounded; apical angle variable. Anterior commissure strongly uniplicate. Beak short, sharp, suberect; foramen large, oval; deltidial plates wide anteriorly, narrow posteriorly, disjunct. Costae strong, subangular, numbering about 26.

Ventral valve flatly convex in side view, forming broad shallow swale in anterior profile. Umbonal region gently swollen. Sulcus broad, shallow, originating on umbo, with 4 to 7 costae. Flanks narrowly rounded; tongue fairly long.

Dorsal valve gently convex in side view, forming fairly high dome with steep sides in anterior view. Valve swollen medially. Fold originating posterior of midvalve, with 5 to 8 costae. Fold moderately elevated above flanks in anterior third.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
280274a	23.7	20.2	24.1	17.5	88	13.9
380274b	23.0	20.5	23.2	15.8	83	12.0
380248	23.3	20.0	25.0	16.5	92	14.8

OCCURRENCE.—Upper Dhruma Formation (Zone not placed): S1613. Tuwaiq Mountain Formation: S154, S459, S800.

TYPES.—Holotype: USNM 380248. Paratypes: USNM 380274a,b, 380617.

DISCUSSION.—This species differs from *Daghanirhynchia daghaniensis* as figured by Muir-Wood (1935, pl. 8: fig. 5a–c) in having more costae and more costae in sulcus. No other Somali species resembles this one.

Daghanirhynchia sulcata, new species, differs from *D. angulocostata*, new species, in being smaller, with less elevated, less angular costae, and less width.

Daghanirhynchia? triangulata, new species

PLATE 7: FIGURES 6–21, PLATE 11: FIGURES 11–15

DIAGNOSIS.—Narrowly triangular *Daghanirhynchia*.

DESCRIPTION.—Triangular, with maximum width at anterior, dorsal valve deeper than ventral valve. Anterolateral extremities narrowly rounded, apical angle acute. Lateral commissure straight. Anterior commissure strongly uniplicate. Beak fairly long, suberect; foramen large; deltidial plates, narrow, disjunct. Costae strong, narrowly rounded, numbering 16–18.

Ventral valve gently convex in lateral view, broadly concave in anterior profile. Median region slightly swollen. Sulcus originating at umbonal region, occupying nearly half valve width, depressed below flanks throughout, strongly so in anterior half. Sulcus occupied by 2 or 3 costae. Tongue long, narrow.

Dorsal valve moderately convex in side view, roundly domed in anterior profile with very steep sides. Fold starting posterior of midvalve, narrow, occupied by 3 or 4 costae, elevated moderately above flanks.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees. Questionmark indicates measurement taken from broken specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380198	21.4	18.2	21.7	16.4	80	12.7
380246	23.7	21.5	20.6?	20.0	78	10.5
380250a	18.0	15.1	17.0	14.6	69	7.5
380380	24.0	20.7	21.8	21.8	79	12.3

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): S1150. Upper Dhruma Formation (Atash member): KK9-112, -117; (Hisyan Member): S1444; (Zone not placed): S1257, S1613.

TYPES.—Holotype: USNM 380246. Paratypes: USNM 380198, 380250a,b, 380380.

DISCUSSION.—This species differs from other species of *Daghanirhynchia* in its narrow, triangular form. The specimens suggest Muir-Wood's (1935) *D. macfadyeni* differing, however, in slightly smaller dimensions, sulcus rarely with two costae, and fold somewhat more elevated at the anterior than the type of *D. macfadyeni*.

Deltarhynchia, new genus

TYPE SPECIES.—*Deltarhynchia triangulata*, new species.

DIAGNOSIS.—Medium to large, triangular, inequivalve, strongly uniplicate with conspicuous narrow fold. Costae thick, angular. Dental plates very long. Median septum reaching midvalve; teeth and sockets corrugated. Crura radulifer.

SPECIMENS STUDIED.—43.

GEOLOGICAL OCCURRENCE.—Bathonian.

ETYMOLOGY.—Greek, *delta* (triangle) plus *rhynchos* (beak).

DISCUSSION.—This genus is characterized by its triangular form, subcarinate fold, and long median septum. It is suggestive of *Gonirhynchia* (Buckman, 1917) in its exterior, differing in having a convex ventral valve and long median septum. *Deltarhynchia* has the appearance of *Daghanirhynchia* but differs in character of fold and sulcus and interior details. Its fold is narrower than that of *Daghanirhynchia*, and it has longer dental plates and thinner, narrower crura. There is resemblance to *Tetrarhynchia* Buckman, 1917, which has similar costation and folding to that of *Deltarynchia*. The high median septum and crura of *Deltarhynchia* are different from those of *Tetrarhynchia* as revealed by serial sections. *Deltarhynchia* differs from *Pycnoria*, new genus, in its more triangular form, gentler folding, long median septum, and less calcification of the shell.

Deltarhynchia compacta, new species

PLATE 7: FIGURES 22–26

DIAGNOSIS.—Small compact *Deltarhynchia*.

DESCRIPTION.—Medium, subtriangular, maximum width anterior to midvalve, sides rounded, anterior margin straight. Apical angle 98°. Dorsal valve strongly convex, ventral valve moderately convex. Anterior commissure strongly, narrowly uniplicate. Beak narrow, short; foramen small, oval. Deltidial plates narrow, disjunct, thick, obliquely elevated. Costae number 16, rounded and separated by spaces narrower than costae.

Ventral valve gently concave in anterior view. Sulcus originating at about midvalve, moderately deep, occupied by 2 costae. Flanks narrowly rounded, steep-sided.

Dorsal valve strongly domed in anterior view with steep, rounded sides. Fold moderately elevatd, rounded, originating posterior to midvalve, with three costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380240: length 16.3, dorsal valve length 13.8, width 16.7, thickness 14.0, apical angle 98°, fold width 6.7.

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1620.

TYPES.—Holotype: USNM 380240.

DISCUSSION.—This species differs from *D. triangulata*, new species, in its smaller size, compact form, less elevated fold and more broadly rounded sides.

Deltarhynchia triangulata, new species

FIGURE 15: PLATE 7: FIGURES 27–43

DIAGNOSIS.—*Deltarhynchia* with narrowly rounded fold.

DESCRIPTION.—Medium to large, triangular, maximum width anterior to midvalve; anterolateral margins narrowly rounded; apical angle usually obtuse. Ventral valve gently convex; dorsal valve strongly convex. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak narrow, short, suberect to erect; foramen small, hypothyridid; deltidial plates disjunct, thick, obliquely elevated. Costae sharply angular about 17.

Ventral valve deeply sulcate in anterior view. Umbonal region narrow, gently swollen. Sulcus originating posterior of midvalve, deepening rapidly, deeply depressed below narrow, rounded flanks in anterior two-thirds. Sulcus with 2 to 4 costae. Tongue long and narrow.

Dorsal valve strongly domed in anterior view, swollen. Fold narrowly rounded, beginning in umbonal region, anteriorly well elevated above rounded, steep flanks. Fold occupying about half valve width, bearing 3 to 5 sharp costae.

Interior: Ventral valve with long divergent dental lamellae, occupying more than half shell surface length (10 mm in specimen 18 mm long).

Dorsal valve interior with high median septum reaching midvalve. Septalium fairly large. Crura radulifer.

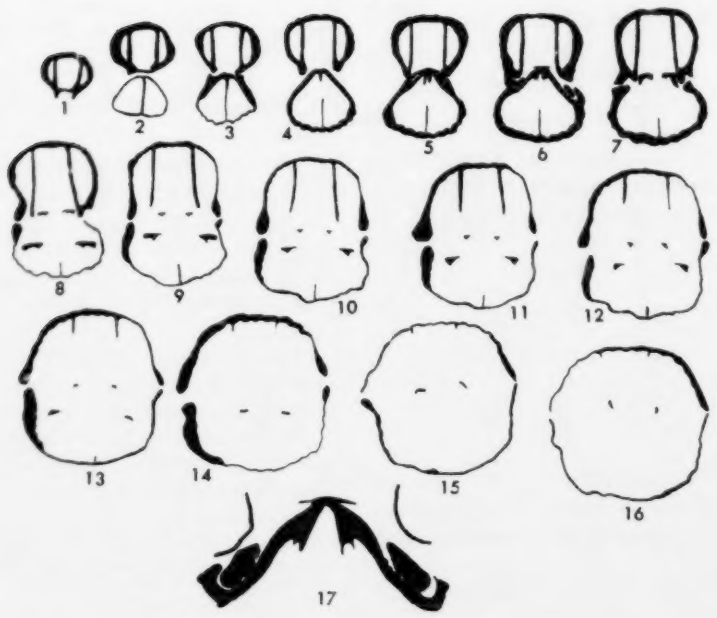


FIGURE 15.—*Deltarhynchia triangulata*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.8(0.8); 2, 0.4(1.2); 3, 0.4(1.6); 4, 0.2(1.8); 5, 0.3(2.1); 6, 0.2(2.3); 7, 0.3(2.6); 8, 0.2(2.8); 9, 0.2(3.0); 10, 0.5(3.5); 11, 0.1(3.6); 12, 0.2(3.8); 13, 0.3(4.1); 14, 0.3(4.4); 15, 0.2(4.6); 16, 0.2(4.8). All structures gone by 5.1 mm; approximately ×2.25. 17, enlargement of cardinalia of section 6; approximately ×4; length 15.8 mm; USNM 380679; Locality S1503.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380202	22.0	18.8	23.2	16.8	94	10.4
380217a	21.8	18.7	20.2	20.0	85	9.0
380369	25.5	21.4	24.6	19.2	94	10.4
380601a	20.4	17.5	20.6	16.0	95	10.0

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1482, S1501, S1503, S1620.

TYPES.—Holotype: USNM 380369. Paratypes USNM 380202, 380217a,b, 380601a,b, 380679.

DISCUSSION.—This species is characterized by triangular outline and narrow subcarinate fold. It differs from *Pycnoria magna*, new species, in its less compact form and the narrowly rounded fold.

The Saudi Arabian specimens are similar to *Rhynchonella subdecorata*, Davidson (1851–1852, appendix to volume 1:21, pl. A: figs. 23–26) from the Bajocian (Inferior Oolite). The English species is more strongly costate and has a stronger fold and sulcus; the fold, however, tapers in a dorsal direction like that of the Saudi Arabian species.

Echyrosia, new genus

TYPE SPECIES.—*Echyrosia costata*, new species.

DIAGNOSIS.—Medium, subtriangular, inequivalve; uniplicate. Strongly costate with long dental plates, narrow septalium, and short median septum.

SPECIMENS STUDIED.—15.

GEOLOGICAL OCCURRENCE.—Bajocian.

ETYMOLOGY.—Greek *echyros* (strong), referring to the strong costae.

DISCUSSION.—*Echyrosia* is conspicuous for its narrow, triangular outline, few strong costae, low narrow fold, and shallow sulcus. The beak is erect; the deltidial plates are narrow, thick, disjunct, and without raised margins. The foramen is oval and small, less than a millimeter wide.

Inside the ventral valve the dental plates are long and slender reaching far beyond the plane of articulation in section. The median septum in the dorsal valve on the other hand is short disappearing, in section, a short distance (3–4 mm) anterior to the beak. The hinge plates appearing at about the same distance

are thin, flattish to convex posteriorly. The crural bases are well developed and the crura are thin and of radulifer type.

Echyrosia suggests a narrow *Cymatorhynchia* in its exterior details but differs in its triangular form and narrow folding. In these respects it differs from *Lacunaerhynchia* and *Septulirhynchia*, both of Almeras, 1966. The interior of *Echyrosia* is similar to that of *Formosarhynchia* Seifert, 1963, but that genus is wider and rounder than *Echyrosia* and has a thicker, less elevated median septum and with crural bases undifferentiated. *Echyrosia* is similar to *Prionorhynchia* Buckman, 1917, the latter being more robust and wider and with longer median septum.

Echyrosia circularis, new species

PLATE 8: FIGURES 1–9

DIAGNOSIS.—Ball-like *Echyrosia*.

DESCRIPTION.—Small, nearly circular with rounded sides and anterior, apical angle slightly obtuse, maximum width at midvalve. Anterior commissure uniplicate. Beak low, sharp, suberect. Foramen moderately large, hypothyridid. Deltidial plates thick, disjunct. Costae narrowly rounded, sparse, numbering 11–14.

Ventral valve gently convex in lateral view, flatly domed with steeply sloping sides in anterior profile. median region gently swollen. Sulcus originating near midvalve, shallow, occupied by two or three costae. Tongue moderately long, serrate at extremity.

Dorsal valve fairly strongly convex in side view, roundly, strongly domed in anterior profile. Fold low, originating on swollen midvalve, moderately elevated at anterior. Flanks rounded, steep.

Interiors not seen.

MEASUREMENTS (in mm).—USNM 380539b: length 18.7, dorsal valve length 16.3, width 17.6, thickness 15.2, apical angle 92°, fold width 11.5.

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1677.

TYPES.—Holotype: USNM 380539b. Paratypes: USNM 380539 a,c,d.

DISCUSSION.—This species differs from *Echyrosia costata*, new species, in its globular form and stronger costae. The lot from which the figured specimen was taken is small, and all specimens including the type are poorly preserved. A larger specimen (USNM 380539b) preserves the globular form and distant costae but has only two costae in the sulcus. It measures 18 mm in width by 19 mm in length.

Echyrosia costata, new species

FIGURE 16; PLATE 8: FIGURES 10–26

DIAGNOSIS.—As for genus.

DESCRIPTION.—Medium, triangular with maximum width anterior to midvalve. Anterior margin rounded, anterolateral extremities rounded; apical angle acute. Dorsal valve deeper, more convex than ventral valve. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak short, narrow, curved, suberect; foramen small, hypothyridid; deltidial plates thick, disjunct to conjunct. Costae strong, angular, numbering 13–17.

Ventral valve gently convex in both profiles, with median depression in anterior view. Umbonal region swollen. Sulcus originating at midvalve, shallow, depressed below flanks in anterior half; flanks narrow, steep. Sulcus with 2 to 4 costae.

Dorsal valve fairly strongly convex in lateral view, strongly domed in anterior profile with steeply sloping sides. Umbonal and median regions swollen. Fold starting posterior to midvalve, low posteriorly, well elevated above flanks in anterior half. Fold occupied by 3 to 4 costae. Flanks convex.

Interior: Ventral valve with divergent dental plates extending about 1/3 valve length.

Dorsal valve with small, narrow, confined septalium; septum short, about 1/6 valve length measured on exterior.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate uncertain measurement, imperfect specimen, or poorly developed fold.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380195a	22.8	20.0	19.6	16.0	80	12.8
380195b	25.0	22.0	23.0?	18.0	85	?
380195c	22.3	18.4	24.0?	18.3	85	14.0?
380195d	20.0	17.8	18.7	13.7	85	10.1
380195e	21.6	18.7	20.6	15.5	88	10.3
380396	21.4	18.5	19.3	16.6	83	11.8
380397	20.5	18.3	18.3	14.9	81	7.8
380597a	24.5	20.2	21.4	18.2	?	14.2

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1485, S1506, S1618, S1677; (Zone not placed): S1250.

TYPES.—Holotype: USNM 380195a. Paratypes: USNM 380195b–e, 380396, 380397, 380597a,b, 380650, 400929.

DISCUSSION.—*Echyrosia costata* is suggestive of *Burmirhynchia* Buckman, 1917, and species of *Deltarhynchia*, new genus. It is, however, more narrowly triangular than either.

Echyrosia expansa, new species

PLATE 17: FIGURES 46–51

DIAGNOSIS.—Widely subpentagonal *Echyrosia*.

DESCRIPTION.—Large, widely subpentagonal, length and width nearly equal; maximum width at midvalve. Anterior nasute, sides somewhat narrowly rounded, apical angle near a right angle. Lateral commissure straight, anterior commissure strongly uniplicate. Beak low, erect, hypothyridid. Deltidial plates disjunct. Costae thick, subangular, separated by spaces wider than costae; numbering 13.

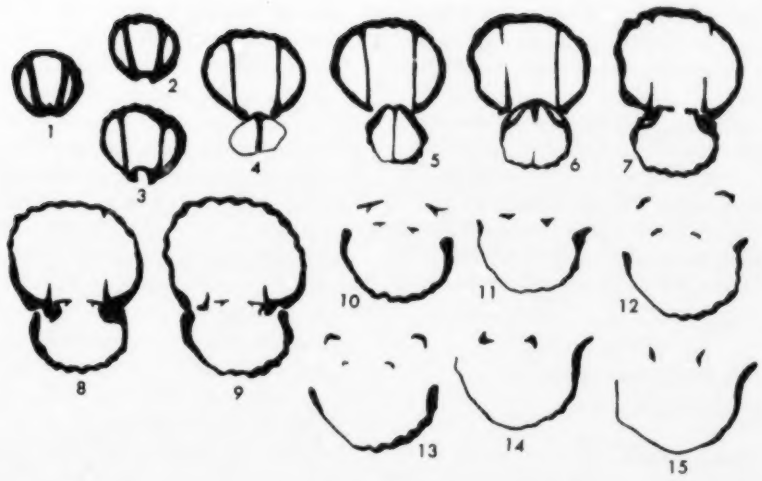


FIGURE 16.—*Echyrosia costata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.4(0.4), 2, 0.7(1.1); 3, 0.5(1.6); 4, 0.4(2.0); 5, 0.5(2.5); 6, 0.3(2.8); 7, 0.3(3.1); 8, 0.3(3.4); 9, 0.3(3.7); 10, 0.2(3.9); 11, 0.2(4.1); 12, 0.4(4.5); 13, 0.3(4.8); 14, 0.2(5.0); 15, 0.2(5.2). Approximately ×2; length 20.7; USNM 380650; Locality S1677.

Ventral valve flatly convex in lateral view, broadly concave in anterior view. Umbonal region swollen. Sulcus wide originating slightly posterior of midvalve, occupied by 3 costae. Tongue long, narrow, serrate distally.

Dorsal valve gently convex in side view, moderately, broadly domed in anterior view with sloping sides. Median region swollen. Fold low, convex, originating posterior of midvalve with 4 costae.

Interior: Dorsal valve with long median septum.

MEASUREMENTS (in mm).—USNM 380563a: length 23.5?, dorsal valve length 22.1, width 24.0, thickness 17.3, apical angle 88°, fold width 14.0.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1677.

TYPES.—Holotype: USNM 380563a. Paratypes: USNM 380563b–d.

DISCUSSION.—This species differs from *Echyrosia costata*, new species, in its wider outline with maximum width at midvalve.

This species suggests *Formosarhynchia* Seifert, 1963, in its external form; internally the dental plates and median septum are short and thin and the crural bases well formed unlike those of *Formosarhynchia*.

Eurysites, new genus

TYPE SPECIES.—*Eurysites transversus*, new species.

DIAGNOSIS.—Transversely to roundly triangular rhynchonellaceans with long, straight beak, large foramen; septalium small, median septum weak.

DESCRIPTION.—Small, transversely elliptical to roundly triangular; Dorsal valve more convex than ventral valve. Lateral commissure straight; anterior commissure usually gently uniplicate. Beak long, straight to suberect; foramen large, hypothyridid. Deltidial plates disjunct, with thickened base and elevated rims. Costae strong, erect, narrowly rounded.

Ventral valve with long widely divergent dental plates; teeth hook-like.

Interior: Dorsal valve with small septalium; short median septum, radulifer crura.

GEOLOGICAL OCCURRENCE.—Bathonian to Callovian.

ETYMOLOGY.—Greek *eurys* (broad).

DISCUSSION.—In its general form and elongated beak *Eurysites* suggests *Flabellirhynchia* Buckman (1917), from the Bajocian of England. Differences appear in the growth form and deltidial plates. One of the conspicuous features of *Flabellirhynchia* is the thickening of the anterior by successive stages of growth. Such thickening does not occur in the Arabian shells. The deltidial plates of *Flabellirhynchia* are conjunct with thickened base and elevated rim but not with thickened circular rim as indicated in the Treatise on Invertebrate Paleontology (Ager, 1965:H615, fig. 9a). The deltidial plates of *Eurysites* have thickened rims, but they do not form a circle and they are disjunct.

Eurysites rotundus, new species

FIGURE 17; PLATE 8: FIGURES 27–49, PLATE 17: FIGURES 1–11

DIAGNOSIS.—Roundly triangular *Eurysites*.

DESCRIPTION.—Small, roundly triangular with rounded

sides and broadly rounded anterior margin; apical angle near 90°. Dorsal valve much more convex than ventral valve. Lateral commissure slightly oblique; anterior commissure uniplicate. Beak long, sharply pointed, straight. Foramen large; deltidal plates disjunct with marginal rims. Costae subangular, high, numbering about 15. Interspaces between costae marked by fine concentric fila.

Ventral valve gently convex in lateral view; medially gently sulcate in anterior profile. Umbonal and median regions swollen. Sulcus originating posterior of midvalve, shallow, depressed below flanks in anterior third, occupied by 2 or 3 costae.

Dorsal valve strongly convex in side view, roundly domed with steep sides in anterior profile. Valve swollen. Fold starting posterior of midvalve, poorly defined, most visible in anterior third. Flanks inflated, moderately steep.

Interior: Serial sections showing thick apex in ventral valve, thick dental plates disappearing before midvalve. In dorsal valve thick hinge plates, short median septum or ridge; crural bases well developed; crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380252	15.0	12.7	15.5	10.6	96	7.4
380399a	15.2	12.7	16.0	11.9	104	7.8
380399b	16.3	13.7	15.8	11.4	104	8.0
380400	12.0	10.0	11.4	8.5	85	5.0
380401	13.3	11.5	12.4	10.0	88	4.0
380618a	15.5	13.4	16.6	11.2	96	7.6
380618b	16.4	14.2	15.7	10.0	96	8.8
380618c	13.3	11.3	15.0	8.6	102	8.2

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1001, S1036, S1046, S1157, S1160, S1440, S1501, S1503; KK8-22, -23, -24.5, -30–35, -30–40, -33–35, -35–38, 35–40; KK8A-34; (*Tulites* Zone): S1747, KK8-39–KK8A-58; (Zone not placed): S1447, S1644. Upper Dhruma Formation (Zone not placed): S1257. Tuwaiq Mountain Formation: S1253, S1460.

TYPES.—Holotype: USNM 380400. Paratypes: USNM 380252, 380256, 380359a,b, 380399a,b, 380401, 380618a–c, 380686.

DISCUSSION.—Triangular form and plump dorsal valves separate this species from the elliptical *E. transversus*, new species.

Eurysites transversus, new species

FIGURE 18; PLATE 8: FIGURES 50–59, PLATE 9: FIGURES 1–16, PLATE 17: FIGURE 12

DIAGNOSIS.—*Eurysites* with transversely elliptical outline.

DESCRIPTION.—Medium size, transversely elliptical, dorsal valve more convex than ventral valve. Maximum width at midvalve. Sides rounded, anterior broadly rounded. Apical angle obtuse. Lateral commissure slightly oblique; anterior commissure narrowly, gently uniplicate. Beak long, straight. Foramen large. Deltidial plates with low marginal rim, disjunct. Costae strong, narrowly rounded with wide interspaces occupied by closely spaced, concentric fila. Costae numbering 11 to 13.

Ventral valve gently to flatly convex in side view, nearly flat with narrow median depression in anterior profile. Umbo narrow, slightly swollen, median region flattened. Sulcus originating near midvalve, deep anteriorly, occupied by 2 or 3 costae.

Dorsal valve moderately convex in side view, moderately domed in anterior profile. Umbonal region somewhat flattened, median region swollen, swelling continued to anterior and flanks. Fold poorly defined, starting at or posterior to midvalve, slightly elevated in anterior third.

Interior: Ventral valve with moderately long dental plates, narrow teeth. Dorsal valve interior with small septalium usually obscured by adventitious shell; short median septum and laterally compressed radulifer crura.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate incomplete or damaged specimen that could not be measured.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380232	16.4	13.3	17.1	10.0	93	6.8
380234	14.3	12.0	18.0	9.7	115	10.0
380366	16.0	13.4	18.8	11.7	113	10.0
380590	13.3	11.9	16.0	8.2	114	6.8
380591	13.9	12.8	17.4	7.2	?	?
380592	15.3	13.0	16.9	8.3	108	7.4

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1001, S1036, S1045, S1157, S1440, KK8-22.5, -25, -34. (*Micromphalites* Zone): KK9-30–40; (Zone not placed): S1447. Upper Dhruma Formation (Zone not placed): S1257, S1471, S1742. Tuwaiq Mountain Formation: S1146, S1460.

TYPES.—Holotype: USNM 380232. Paratypes: USNM 380234, 380366, 380390, 380450, 380590, 380591, 380592, 380680.

DISCUSSION.—This species differs from *Eurysites rotundus*, new species, in its widely elliptical outline.

Gibbirhynchia Buckman, 1917

The specimens here referred to *Gibbirhynchia*, although conforming to the characters outlined for the genus in exterior details, differ to some extent from the genus in interior details and among themselves. *Gibbirhynchia rotundata*, new species,

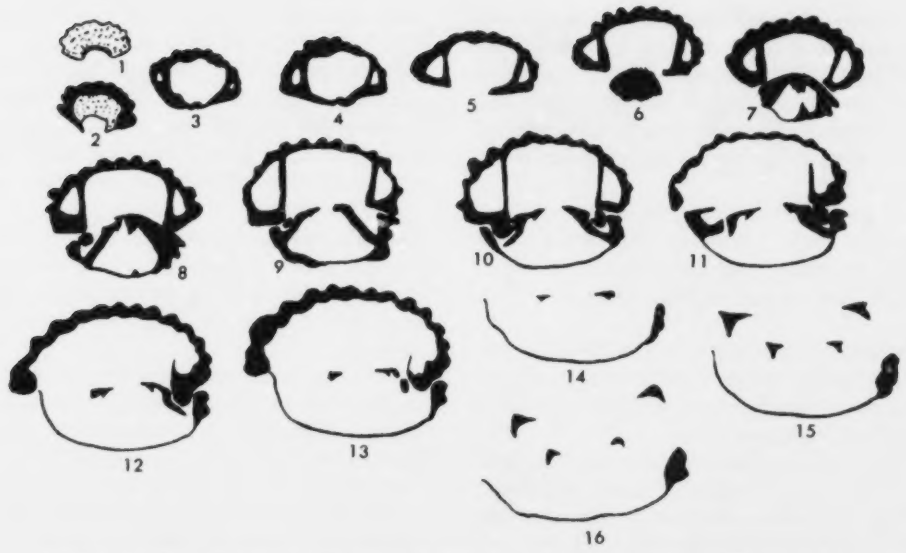


FIGURE 17.—*Eurysites rotundus*, new species (numbers show distance between sections in mm and (in parentheses) distance from beak): 1, 0.7(0.7); 2, 0.3(1.0); 3, 0.4(1.4); 4, 0.3(1.7); 5, 0.2(1.9); 6, 0.4(2.3); 7, 0.2(2.5); 8, 0.3(2.8); 9, 0.3(3.1); 10, 0.2(3.3); 11, 0.2(3.5); 12, 0.4(3.9); 13, 0.2(4.1); 14, 0.2(4.3); 15, 0.1(4.4); 16, 0.2(4.6). Approximately ×3; length 13.6 mm; USNM 380686; Locality KK8-30-35.

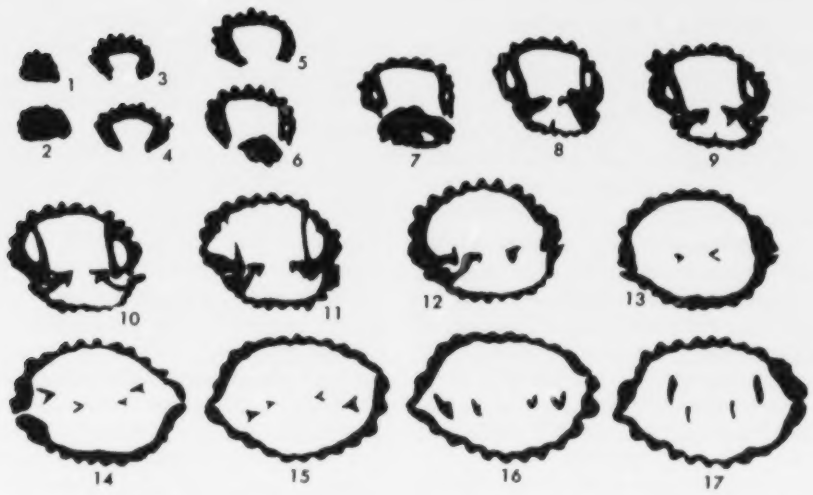


FIGURE 18.—*Eurysites transversus*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.3(0.3); 2, 0.2(0.5); 3, 0.6(1.1); 4, 0.3(1.4); 5, 0.4(1.8); 6, 0.4(2.2); 7, 0.1(2.3); 8, 0.2(2.5); 9, 0.4(2.9); 10, 0.2(3.1); 11, 0.2(3.3); 12, 0.2(3.5); 13, 0.2(3.7); 14, 0.3(4.0); 15, 0.3(4.3); 16, 0.2(4.5); 17 0.1(4.6). All structures gone at 4.9 mm; approximately ×2; length 16.1 mm; USNM 380680; Locality KK8-34.

has a typical ventral valve interior but a long median septum. *G. pulcher*, new species, is atypical in the details of its ventral interior; its short median septum, however, conforms to that dorsal character in the genus.

In Europe and part of Asia *Gibbirhynchia* is confined to the Lias. Specimens from Saudi Arabia here referred to *Gibbirhynchia* range from Bajocian to Bathonian (Middle Dhruma Formation, *Micromphalites* Zone).

Gibbirhynchia costata, new species

PLATE 9: FIGURES 17–23

DIAGNOSIS.—Large strongly costate *Gibbirhynchia*.

DESCRIPTION.—Large for genus, roundly triangular with rounded anterior and lateral margins. Apical angle acute. Dorsal valve slightly more convex than ventral valve. Maximum width at about midvalve. Lateral commissure straight; anterior commissure narrowly uniplicate. Beak incurved; foramen small, hypothyridid. Deltidial plates disjunct with marginal rims posteriorly. Costae, numbering 15, angular.

Ventral valve unevenly convex in side view with strongly rounded umbonal region, moderately convex median and anterior regions. Anterior profile gently convex or slightly concave with narrowly rounded, steep flanks. Sulcus originating at midvalve, depressed below flanks at anterior third. Sulcus with 3 costae. Tongue moderately long.

Dorsal valve moderately, evenly convex in side view, roundly domed with steep sides in anterior profile. Umbonal and median regions swollen. Fold inconspicuous, starting at midvalve, slightly elevated above flanks at anterior, with 4 costae.

Interior: Ventral valve with divergent dental plates. Dorsal valve with short median septum, narrow septalium.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate incomplete or damaged specimen that could not be measured.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380395a	13.7	11.4	12.4	10.6	81	6.0
380395b	15.2	12.3	14.0	?	80	6.0
380395c	16.0	13.7	?	14.6	87	6.4

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK6.

TYPES.—Holotype: USNM 380395a. Paratypes: 380395b-c.

DISCUSSION.—Distinguished from other species of *Gibbirhynchia* described herein by its strong, distant costation, and large size.

Gibbirhynchia magna, new species

PLATE 9: FIGURES 43–55

DIAGNOSIS.—Large *Gibbirhynchia* with numerous costae.

DESCRIPTION.—Large for genus, roundly triangular to subcircular; dorsal valve slightly deeper than ventral valve. Anterior margin gently rounded, sides strongly rounded; apical angle variable. Lateral commissure nearly straight; anterior commissure strongly, narrowly uniplicate. Beak short, erect; foramen small; deltidial plates thick, disjunct with marginal rims. Finely costate, costae subangular crowded, numbering 22.

Ventral valve moderately convex in side view, flatly convex with median region having shallow depression in anterior view. Umbonal region swollen. Sulcus originating posterior of midvalve, shallow, occupied by 4–6 costae; slightly depressed below narrow rounded flanks in anterior third. Tongue short, rounded.

Dorsal valve strongly convex in side view, roundly domed with steep sides in anterior profile. Umbonal and median regions swollen, swelling continued as low fold originating near midvalve. Fold occupied by 5 to 7 costae. Fold elevated above flanks in anterior third.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380233a	17.3	14.0	16.4	13.5	85	8.2
380233b	16.4	14.3	16.2	14.3	82	8.3
380233c	13.7	11.4	13.6	10.6	102	5.5

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK6.

TYPES.—Holotype: USNM 380233a. Paratypes: USNM 380233b–d.

DISCUSSION.—This is the largest *Gibbirhynchia* in the collection. It differs from *G. costata*, new species, which is also a large species, in having a more pronounced fold, and from *G. rotundata* in the more numerous costae on fold and sulcus.

Gibbirhynchia mundula, new species

PLATE 9: FIGURES 30–36

DIAGNOSIS.—Medium size *Gibbirhynchia* with 4 costae in deep sulcus.

DESCRIPTION.—Rotund, sides and anterior margin rounded; apical angle acute. Dorsal valve more convex than ventral valve. Lateral commissure oblique; anterior commissure narrowly uniplicate. Beak, short, suberect; foramen large; deltidial plates narrow, obliquely elevated, disjunct. Costae

subangular, crowded, numbering about 22.

Ventral valve moderately, evenly convex in side view; flatly convex with median depression in anterior profile. Umbonal region swollen. Sulcus starting at midvalve, strongly depressed below narrow flanks in anterior half. Sulcus with 4 costae. Tongue narrow, long, pointed.

Dorsal valve evenly, strongly convex in side view, forming round steep-sided dome in anterior profile. Valve greatly swollen. Fold narrow, starting at about midvalve, moderately elevated above flanks in anterior half, with 5 costae.

MEASUREMENTS (in mm).—USNM 380253: length 14.6, dorsal valve length 13.0, width 13.7, thickness 11.7, apical angle 86°, fold width 6.5.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1501.

TYPE.—Holotype: USNM 380253.

DISCUSSION.—*Gibbirhynchula mundula* has a less incurved beak and more costae than *G. costata*, new species. *Gibbirhynchia rotundata*, new species, is rounder, less strongly costate, and with more incurved beak than *G. mundula*.

Gibbirhynchia parva, new species

PLATE 9: FIGURES 37–42

DIAGNOSIS.—Very small *Gibbirhynchia* with numerous costae.

DESCRIPTION.—Small, subpentagonal; sides rounded, anterior margin slightly reentrant; apical angle acute. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak small, erect; foramen small; deltidial plates partially concealed. Costae flatly convex, numerous, crowded, numbering 28 or 29.

Ventral valve gently convex in side view, most convex in umbonal region; gently convex with median depression in anterior profile. Umbonal region swollen. Sulcus originating at midvalve, wide, deep. Sulcus with 5 costae. Tongue short, rounded.

Dorsal valve fairly strongly convex in side view; narrowly domed with steeply sloping sides in anterior profile. Valve strongly swollen. Fold poorly defined, best seen at anterior commissure, marked by 6 costae.

MEASUREMENTS (in mm).—USNM 380305a: length 9.6, dorsal valve length 7.6, width 9.4, thickness 7.7, apical angle 82°, fold width 3.0.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK6.

TYPES.—Holotype: USNM 380305a. Paratype: USNM 380305b.

DISCUSSION.—This species differs from all others described herein by its small size and numerous, fine costae.

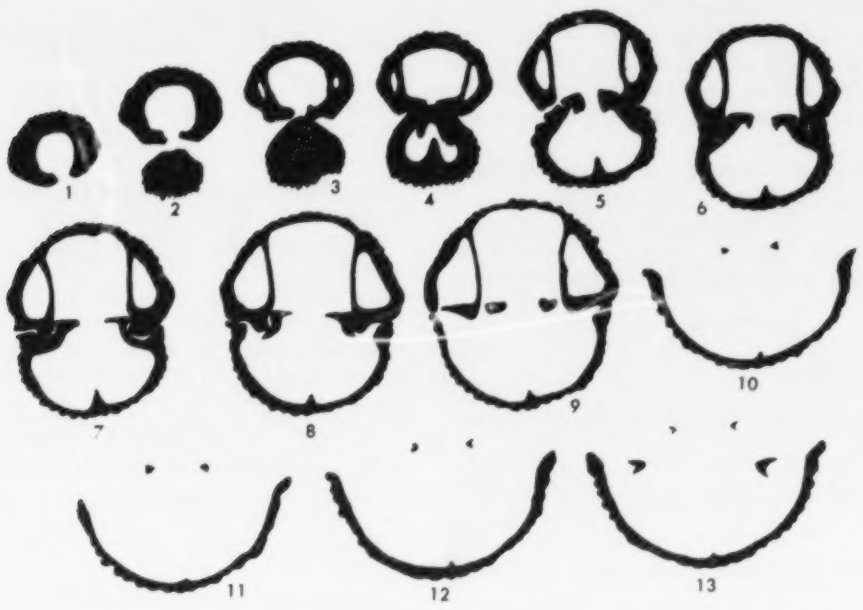


FIGURE 19.—*Gibbirhynchia pulcher*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.2(0.8); 3, 0.1(0.9); 4, 0.15(1.05); 5, 0.25(1.3); 6, 0.3(1.6); 7, 0.1(1.7); 8, 0.2(1.9); 9, 0.1(2.0); 10, 0.4(2.4); 11, 0.1(2.5); 12, 0.2(2.7); 13, 0.1(2.8). Approximately ×4; length 10.5 mm; USNM 380674; Locality KK7-45.

Gibbirhynchia pulcher, new species

FIGURE 19; PLATE 9: FIGURES 24–29

DIAGNOSIS.—Medium size for genus, finely costate.

DESCRIPTION.—Medium for genus, subcircular, sides rounded, anterior subtruncate; apical angle slightly obtuse. Lateral commissure slightly oblique; anterior commissure strongly uniplicate. Beak low, erect; foramen small, elliptical; deltidial plates disjunct, anteriorly thickened. Surface finely costate, costae crowded, rounded, numbering about 28. Ventral valve moderately convex in side view, nearly flat with gentle median depression in anterior profile. Sulcus starting at midvalve, wide shallow, moderately depressed below flanks in anterior half, occupied by 6 costae. Flanks steep, rounded. Tongue long, rounded.

Dorsal valve moderately convex, more convex than ventral valve in side view; roundly domed with steep sides in anterior profile. Fold inconspicuous, starting at midvalve, very slightly raised above flanks in anterior half. Fold occupied by 7 costae.

MEASUREMENTS (in mm).—USNM 380259: length 12.2, dorsal valve length 9.8, width 11.4, thickness 9.7, apical angle 92°, fold width 6.0.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK7-35, -45, -52.

TYPES.—Holotype: USNM 380259. Paratype: USNM 380674.

DISCUSSION.—The finely costate shell, circular form, fairly deep sulcus, and low fold are characters separating this species from *G. costata*, *G. mundula*, *G. rotundata*, and *G. magna*, all new species. It is much larger than *G. parva*, new species. *Gibbirhynchia subcircularis* has stronger costae and is smaller than *G. pulcher*.

The interior of *G. pulcher* differs from that of *G. rotundata*, new species, in lacking the muscle pits at the inner base of the dental plates. The median septum of the dorsal valve is also shorter than that of *G. rotundata*, and the shell is thinner than that of the latter.

Gibbirhynchia rotundata, new species

FIGURE 20; PLATE 9: FIGURES 56–65

DIAGNOSIS.—Spherical *Gibbirhynchia* with numerous costae.

DESCRIPTION.—Small, subcircular, ball-like, slightly longer than wide with maximum width at about midvalve. Dorsal valve more convex than ventral valve. Anterior margin gently rounded, sides strongly rounded; apical angle near 90°. Lateral commissure oblique; anterior commissure strongly, widely uniplicate. Beak small, low, erect. Foramen small; deltidial plates concealed. Costae rounded, about 20.

Ventral valve gently convex in lateral view, flatly convex with median depression in anterior profile. Umbonal region swollen. Sulcus originating just posterior to midvalve, shallow, depressed slightly below narrow flanks in anterior half, occupied by 3 or 4 costae. Tongue long, narrowly rounded.

Dorsal valve strongly convex in side view, narrowly domed with steep sides in anterior profile. Umbonal and median regions swollen. Fold low, rounded, starting near midvalve slightly elevated above convex flanks in anterior, occupied by 4 or 5 costae.

Interior: Serial sections show muscle pits at inner base of dental plates characteristic of genus. Median septum of dorsal valve longer than that usual in *Gibbirhynchia*.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380251a	12.0	11.3	13.0	12.8	89	6.7
380251b	12.6	10.7	12.2	12.2	90	5.7

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK7-35. (*Ermoceras* Zone): S1661.

TYPES.—Holotype: USNM 380251a. Paratypes: USNM 380251b, 400923.

DISCUSSION.—This species is characterized by its ball-like form and subdued fold, which set it off from *Gibbirhynchia mundula*, new species. It is very like *Gibbirhynchia sphaerica*, new species, from the *Micromphalites* Zone differing from that species in its more numerous costae and wider sulcus.

Gibbirhynchia sphaerica, new species

PLATE 10: FIGURES 18–30

DIAGNOSIS.—Large, coarsely costate, with closely crowded costae and subdued fold and sulcus.

DESCRIPTION.—Large for the genus, spherical in all profiles; anterior subtruncate; dorsal valve more convex than ventral valve; apical angle obtuse. Lateral commissure straight; anterior commissure uniplicate. Beak short, small, suberect to erect; foramen narrow; deltidial plates discrete. Costae strong, rounded, 12–14.

Ventral valve moderately convex in lateral view, flatly convex with short steep lateral slopes. Sulcus originating at about midvalve, shallow, poorly defined anteriorly, occupied by 2 costae. Tongue fairly wide, short.

Dorsal valve strongly convex in both profiles, with long steep slopes. Fold beginning on umbo, low, slightly elevated at anterior, occupied by two costae.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates that imperfect specimen could not be measured for that character; + indicates that measurement is estimated.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380238a	14.4	12.4	14.6	13.5	100	7.0
380449a	15.7	14.1	17.1	15.0	103	7.3
380567	14.3	11.3	13.7+	11.0+	?	7.6

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): S1496; KK9-14, -15.5.

TYPES.—Holotype: USNM 380238a. Paratypes: USNM 380238b, 380567, 380449a–c, 380567.

DISCUSSION.—This species differs from all except *G. costata*, new species, described herein in its spherical shape and strong costae. It differs from *G. costata* in its closely crowded costae and larger apical angle.

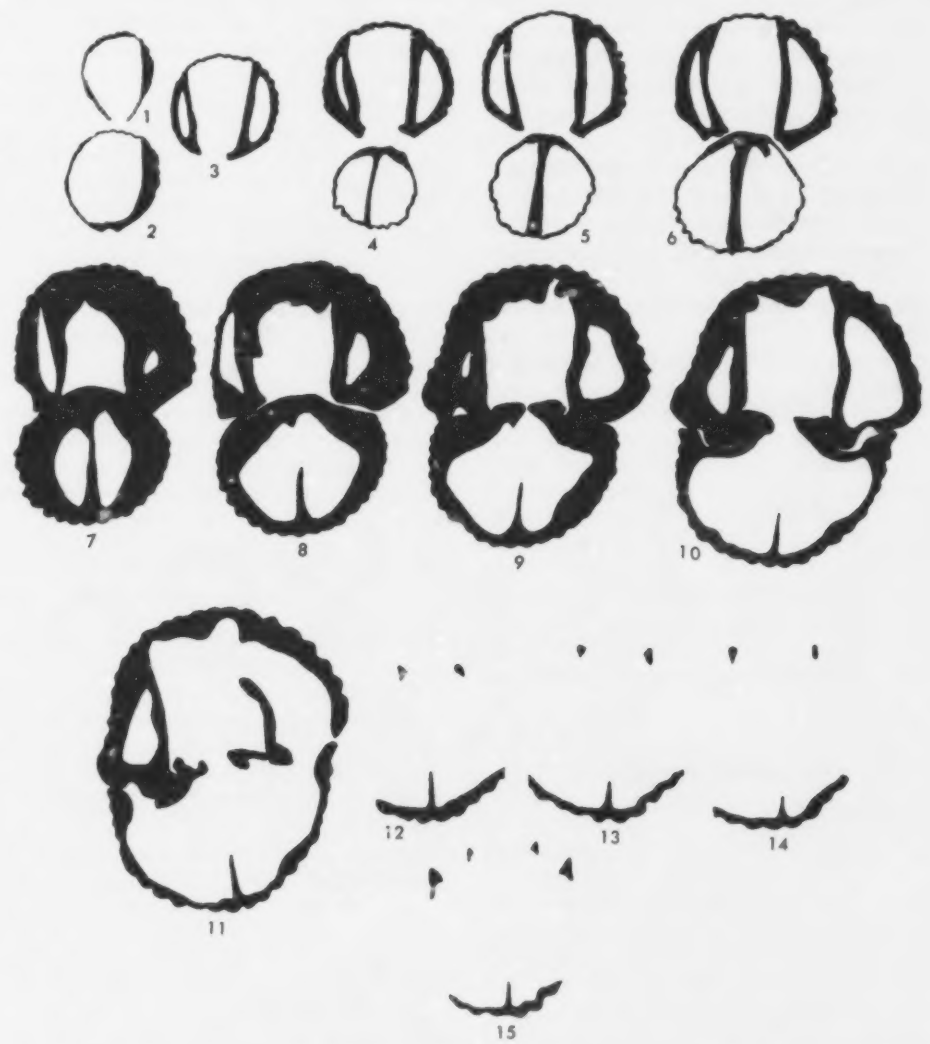


FIGURE 20.—*Gibbirhynchia rotundata*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.5(0.5); 2, 0.4(0.9); 3, 0.6(1.5); 4, 04(1.9); 5, 0.3(2.1); 6, 0.2(2.3); 7, 0.2(2.5); 8, 0.3(2.8)); 9, 0.3(3.1); 10, 0.3(3.4); 11, 0.2(3.6); 12, 0.3(3.9); 13, 0.3(4.2); 14, 0.3(4.5); 15, 0.2(4.7). Approximately ×3; length 13.6 mm; USNM 400923; Locality KK7-35.

Gibbirhynchia subcircularis, new species

PLATE 10: FIGURES 1–6

DIAGNOSIS.—Small for genus, ball-like with fairly strong costae.

DESCRIPTION.—Small, nearly circular, nearly equivalve. Sides and anterior margin rounded. Apical angle acute. Lateral commissure straight; anterior commissure arcuately uniplicate. Beak short, erect; foramen fairly large; deltidial plates, disjunct, anteriorly thickened. Costae narrowly angular, width of interspaces about equal to those of costae; costae about 18.

Ventral valve fairly strong convex in side view; gently convex with medial depression in anterior profile. Valve swollen. Sulcus obscure, starting posterior to midvalve, occupied by 4 costae. Flanks steep, rounded. Tongue short, broadly rounded.

Dorsal valve fairly strongly convex in side view, strongly domed with precipitous sides in anterior view. Fold barely distinguishable, beginning posterior to midvalve, best defined at anterior where ventral tongue is joined. Fold with 5 costae.

Interior: Ventral valve with divergent dental plates extending 1/3 surface length.

MEASUREMENTS (in mm).—USNM 380266a: length 10.7, dorsal valve length 9.0, width 9.8, thickness 9.0, apical angle 85°, fold width 4.0.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1618.

TYPES.—Holotype: USNM 380266a. Paratype: USNM 280266b.

DISCUSSION.—This species is smaller than others described herein except *Gibbirhynchia parva*, new species, from which it differs in shape and in having much stronger costae.

Globirhynchia Buckman, 1917

Globirhynchia concinna, new species

PLATE 10: FIGURES 37–44

DIAGNOSIS.—Small triangular *Globirhynchia* with length and width nearly equal.

DESCRIPTION.—Small, roundly triangular, maximum width anterior to midvalve. Dorsal valve more convex than ventral valve. Sides and anterior rounded, apical angle obtuse. Lateral commissure straight; anterior commissure arcuately uniplicate. Beak short, suberect. Foramen small; deltidial plates disjunct, with marginal rims. Costae strong, subangular, numbering 18.

Ventral valve gently convex in side view; broadly convex with shallow median sulcus in anterior profile. Sulcus originating posterior of midvalve, shallow, depressed below narrow, convex flanks in anterior half. Sulcus occupied by 2 or 3 costae.

Dorsal valve fairly strongly convex in side view, somewhat narrowly domed with sloping sides in anterior profile. Valve strongly swollen medially. Fold beginning on umbonal region, low elevated moderately in anterior two-thirds. Fold occupied by 3 or 4 costae.

Interior: Ventral valve with dental plates extending 1/5 valve surface length. Dorsal valve with low, short median septum extending about 1/3 valve surface length. Septalium short, narrow low.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380243a	15.8	14.0	15.8	10.0	91	7.8
380557a	15.5	13.7	15.0	11.5	90	8.3
380557b	14.2	12.5	14.2	9.0	91	6.6
380557d	13.6	12.0	13.8	8.5	95	7.3
380558a	16.5	14.4	16.5	10.7	93	8.0
380558b	15.2	13.7	16.4	9.4	101	7.2
380558c	14.9	13.2	15.0	10.0	91	6.7
380559	17.7	15.6	17.7	10.0	90	9.0

OCCURRENCE.—Dhruma Formation (*Tulites* Zone): S1244, S1486, S1488, S1621, S1738. (*Micromphalites* Zone): S1500; (Zone not placed): S1414, S1449, S1468.

TYPES.—Holotype: USNM 380243a. Paratypes: USNM 380243b, 380557a–e, 380558a–e, 380559.

DISCUSSION.—This species differs from *Globirhynchia subtriangulata*, new species, in its smaller size, and length and width nearly equal.

Globirhynchia? crassa, new species

PLATE 10: FIGURES 7–12

DIAGNOSIS.—Small circular, inflated valves, strong costae.

DESCRIPTION.—Small, subcircular, rotund, maximum width at midvalve. Sides and anterior rounded, apical angle obtuse. Lateral commissure oblique; anterior commissure uniplicate. Beak short, suberect; foramen small; deltidial plates disjunct with marginal rims. Costae strong, subangular, numbering 13.

Ventral valve gently convex in side view, broadly and gently convex in anterior view with median region slightly concave. Umbonal region swollen. Sulcus starting on umbo, deepening anteriorly, depressed below flanks from midvalve to anterior margin. Tongue fairly long, occupied by 2 or 3 costae.

Dorsal valve moderately convex in lateral view, strongly domed in anterior view with steeply sloping sides. Valve swollen. Fold originating posterior of midvalve, moderately elevated above convex flanks. Fold occupied by 3 or 4 costae.

Interior: Ventral valve with dental plates occupying a quarter valve surface length. Dorsal valve interior with small, short septalium and thin median septum extending almost to midvalve.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380255	13.3	11.4	12.8	9.5	103	6.3
380568	13.7	12.6	13.5	10.6	92	7.2
380569b	13.3	12.0	14.0	9.8	110	8.8
380569c	13.6	12.3	13.2	9.5	108	9.3

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1485, S1506, S1617, S1677.

TYPES.—Holotype: USNM 380255. Paratypes: USNM 380568, 380569a–c.

DISCUSSION.—*Globirhynchia? crassa*, new species, is a rather plump species which differs from *G. dubia*, new species, in stronger costation and from *G. sphaerica*, new species, in smaller size and much less inflated valves.

Globirhynchia? dubia, new species

PLATE 10: FIGURES 31–36

DIAGNOSIS.—Rotund like *G.? crassa*, new species, but with more numerous costae.

DESCRIPTION.—Small, globular, maximum width at midvalve; dorsal more convex than ventral valve. Sides and anterior rounded; apical angle near 90°. Lateral commissure straight; anterior commissure uniplicate. Beak erect, foramen small, deltidial plates posteriorly rimmed. Costae strong, narrowly rounded, numbering 17–19.

Ventral valve gently convex in side view, gently domed in anterior profile. Umbonal and median regions swollen. Sulcus starting at midvalve, poorly defined, seen best in anterior third, occupied by 2 to 4 costae. Tongue short.

Dorsal valve evenly and moderately convex in side view, moderately domed in anterior profile. Valve swollen. Fold starting at midvalve, defined clearly in anterior third. Sulcus occupied by 3 to 5 costae.

Interior: Ventral valve with long dental plates. Dorsal valve interior with small septalium and septum reaching to midvalve.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380262	12.3	10.7	12.1	9.7	84	6.5
380619	13.4	11.7	12.8	10.4	89	7.7

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1618, S1679; (*Thambites* Zone): S1501; (*Micromphalites* Zone): S1500; (Zone not placed): S1468.

TYPES.—Holotype: USNM 380262. Paratype: USNM 380619.

DISCUSSION.—This is a plump species like *G.? crassa*, new species, differing from that species in its more numerous costae.

Globirhynchia subtriangulata, new species

FIGURE 21; PLATE 10: FIGURES 45–55, PLATE 17: FIGURES 28–37

DIAGNOSIS.—Medium sized *Globirhynchia*.

DESCRIPTION.—Medium size, compact, subtriangular. Anterior and sides rounded; apical angle obtuse. Dorsal valve more convex than ventral valve. Lateral commissure straight, anterior commissure broadly, arcuately uniplicate. Beak short, narrow, suberect; foramen small. deltidial plates disjunct, anteriorly thickened with elevated marginal rims posteriorly. Costae strong, subangular, elevated, numbering about 17.

Ventral valve moderately convex in side view, gently concave in anterior profile. Umbonal region swollen. Sulcus originating on umbo, shallow to moderately depressed, occupied by 1 to 3 costae. Tongue short. Sulcus depressed below flanks in anterior third to half. Flanks narrow, rounded.

Dorsal valve strongly convex in side view, strongly domed with steep rounded sides in anterior profile. Valve strongly swollen. Fold beginning on umbo, barely perceptible at its place of origin, only slightly elevated over narrow flanks in anterior half, occupied by 2 to 4 costae.

Interior: Ventral valve with long dental plates. Dorsal valve with small septalium, fairly short median septum, radulifer crura.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380254	14.0	12.5	15.0	9.4	95	6.5
380448a	17.8	15.7	18.3	10.8	95	9.0
380448b	16.9	15.3	19.0	11.4	111	14.4
380502	16.5	14.6	17.3	11.8	97	7.3
380503	16.6	15.0	17.6	11.0	92	7.6

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1440, (*Tulites* Zone): S1244, S1629, S1738; (*Micromphalites* Zone): S1424, S1496; S1498, KK9-16, -20, -20.5, -21, -52.5, -53; (*Dhrumaites* Zone): S1425. (Zone not placed): S1179, S1258.

TYPES.—Holotype: USNM 380448a. Paratypes: USNM 380254, 380448b, 380502, 380503, 380682.

DISCUSSION.—This species is similar to *G. concinna*, new species, differing in its larger size, and somewhat wider and more convex valves. It differs from *G. triangulata*, new species, in its smaller size and less inflated valves. The English species *G. subobsoleta* (Davidson, 1851–1852) is somewhat larger than the Saudi Arabian species, has more costae in fold and sulcus, and more on the flanks.

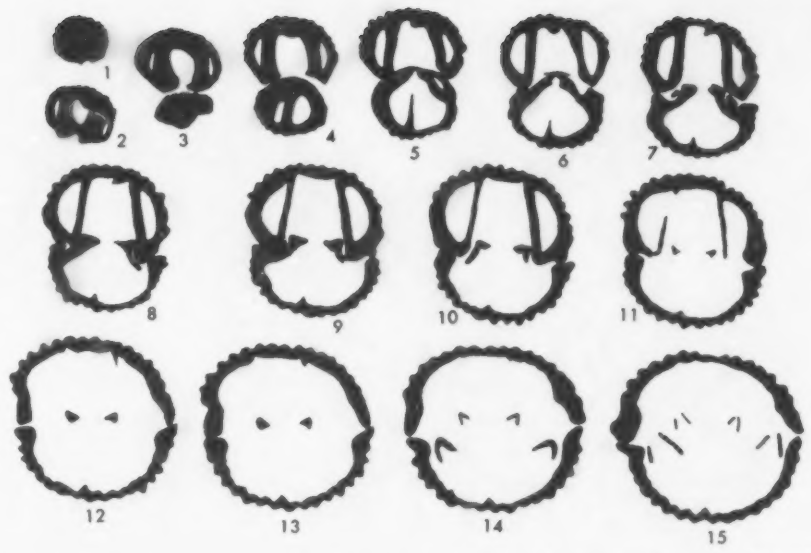


FIGURE 21.—*Globirhynchia subtriangulata*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.8(0.8); 2, 0.4(1.2); 3, 0.3(1.5); 4, 0.3(1.8); 5, 0.6(2.4); 6, 0.1(2.5); 7, 0.3(2.8); 8, 0.3(3.1); 9, 0.4(3.5); 10, 0.2(3.7); 11, 0.2(3.9); 12, 0.2(4.1); 13, 0.2(4.3); 14, 0.2(4.5); 15, 0.2(4.7). All structures disappear at 5.2 mm; approximately ×2; length 16.2 mm; USNM 380682; Locality KK9-21.

Globirhynchia triangulata, new species

FIGURE 22; PLATE 11: FIGURES 1–5

DIAGNOSIS.—Fairly large *Globirhynchia* with fairly strong fold.

DESCRIPTION.—Medium size, roundly triangular, maximum width anterior to midvalve. Sides and anterior margin rounded, apical angle variable. Dorsal valve more strongly convex than ventral valve. Lateral commissure straight, anterior commissure broadly, arcuately uniplicate. Beak short, suberect; foramen small; deltidial plates narrow, not marginally thickened, disjunct. Costae, numbering 16–20 subangular, erect.

Ventral valve evenly and gently convex in lateral view, gently convex with slight median depression in anterior profile. Umbonal and median regions moderately swollen. Sulcus shallow, originating at midvalve, occupied by 3 or 4 costae. Flanks rounded, slightly elevated above sulcus in anterior third. Tongue fairly long.

Dorsal valve moderately convex in side view, moderately domed with sloping sides in anterior profile. Umbonal and median regions strongly swollen. Anterior slope convex. Lateral slopes steep. Fold originating at midvalve, poorly defined, barely discernible in anterior half, with 4 or 5 costae.

Interior: Ventral valve with long thin dental plates; short pedicle collar. Dorsal valve interior with delicate median septum extending to midvalve, supporting small septalium.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate estimated measurement and fold not developed (or not preserved), respectively.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380196a	20.0	17.4	20.6	15.8	101	12.0
380556a	16.8	14.6	16.1	10.3	84	7.6?
380556b	16.0	14.4	16.2	12.5	91	8.6
380556c	17.0	14.8	16.4	11.0	86	8.7
380556d	15.8	13.4	15.8	11.3	86	7.6
380570a	15.8	13.7	14.8	10.6	92	?
380570b	16.6	14.7	16.0	12.5	86	?
380570c	18.5	16.0	18.4	13.5	90	8.0

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1618, S1695.

TYPES.—Holotype: USNM 380196a. Paratypes: USNM 380196b–d, 380556a–d, 380570a–c, 380681.

DISCUSSION.—This species differs from *G. subtriangulata*, new species, in being larger, with more costae and more inflated valves. It is suggestive of the English *G. obsoleta* (Davidson, 1851–1852) differing in its plumper valves,

Heteromychus, new genus

TYPE SPECIES.—*Heteromychus magnificus*, new species.

DIAGNOSIS.—Large, oval, subequivalve, uniplicate to quad-

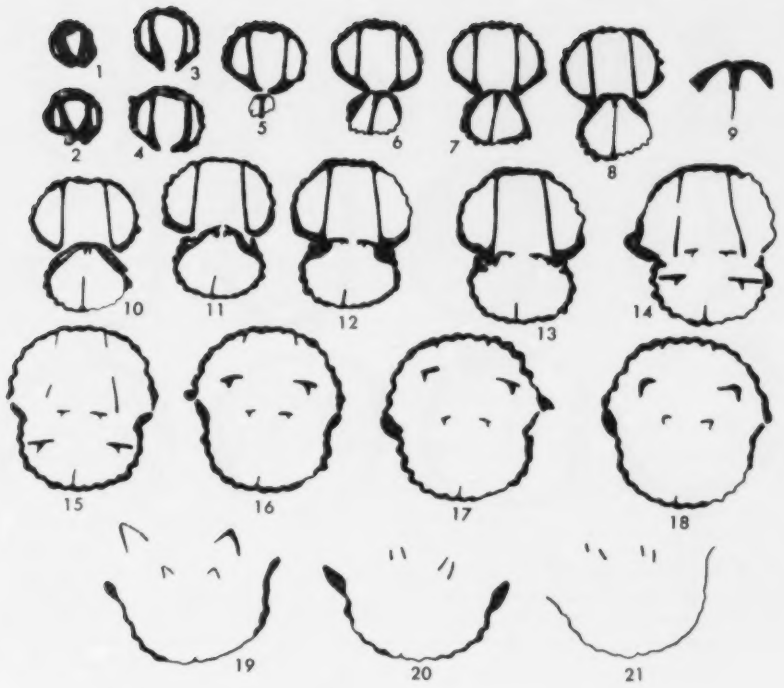


FIGURE 22.—*Globirhynchia triangulata*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.7(0.7); 2, 0.5(1.2); 3, 0.2(1.4); 4, 0.4(1.8); 5, 0.4(2.2); 6, 0.3(2.5); 7, 0.2(2.7); 8, 0.3(3.0); 9, detail of number 8, ×4, 10, 0.2(3.2); 11, 0.3(3.5); 12, 0.3(3.8); 13, 0.2(4.0); 14, 0.2(4.2); 15, 0.3(4.5); 16, 0.3(4.8); 17, 0.1(4.9); 18, 0.2(5.1); 19, 0.6(5.7); 20, 0.4(6.1); 21, 0.2(6.3). Approximately ×3; length 16.9mm; USNM 380681; Locality S1618.

riplicate. Beak small, closely appressed on dorsal umbo; finely costate, costae flatly convex. Ventral valve with long dental plates. Dorsal valve with long median septum, small, shallow septalium and large cardinal process.

SPECIMENS STUDIED.—42.

GEOLOGICAL OCCURRENCE.—Late Bathonian to Callovian.

ETYMOLOGY.—Greek *heteros* (different) plus *mychus* (inmost part).

DISCUSSION.—This genus is most like *Conarosia*, new genus, in external form except for its tendency to develop a quadrate anterior. In this character it is like *Colpotoria*, new genus, which is strongly quadrate anteriorly but with a narrow tapering posterior unlike that of *Heteromychus*. The interior of *Colpotoria* differs from that of *Heteromychus* in having much thickened structures, poorly defined septalium, and no cardinal process.

Heteromychus differs from *Conarosia* in its narrow apex and internally, in its different development of the septalium, which is shallow and open at the plane of articulation. The cardinal process, which resembles that of *Xenorina ovata*, new species, is not present in *Conarosia*. Most of the specimens of this species are badly damaged by crushing. Some of the crushed forms however show the quadrate anterior folding.

Heteromychus magnificus, new species

FIGURES 23, 24; PLATE 5: FIGURES 26–28, PLATE 18: FIGURES 37–46

DIAGNOSIS.—Large, oval *Heteromychus* with inflated valves and quadrate anterior.

DESCRIPTION.—Large, roundly oval, valves swollen, subequal in depth. Lateral margins gently rounded, anterolateral extremities broadly rounded. Anterior quadrilobate in adults. Lateral commissure somewhat sigmoidal; anterior commissure uniplicate. Beak small, erect, close to dorsal umbo. Finely costate, costae flatly convex, about 36 in holotype.

Ventral valve fairly strongly convex in lateral view, flatly domed with narrow steep flanks in anterior view. Most convex in umbonal region. Sulcus shallow, originating at about midvalve with low narrow median fold.

Dorsal valve fairly evenly, strongly convex in side view, strongly domed with steep rounded lateral slopes in anterior

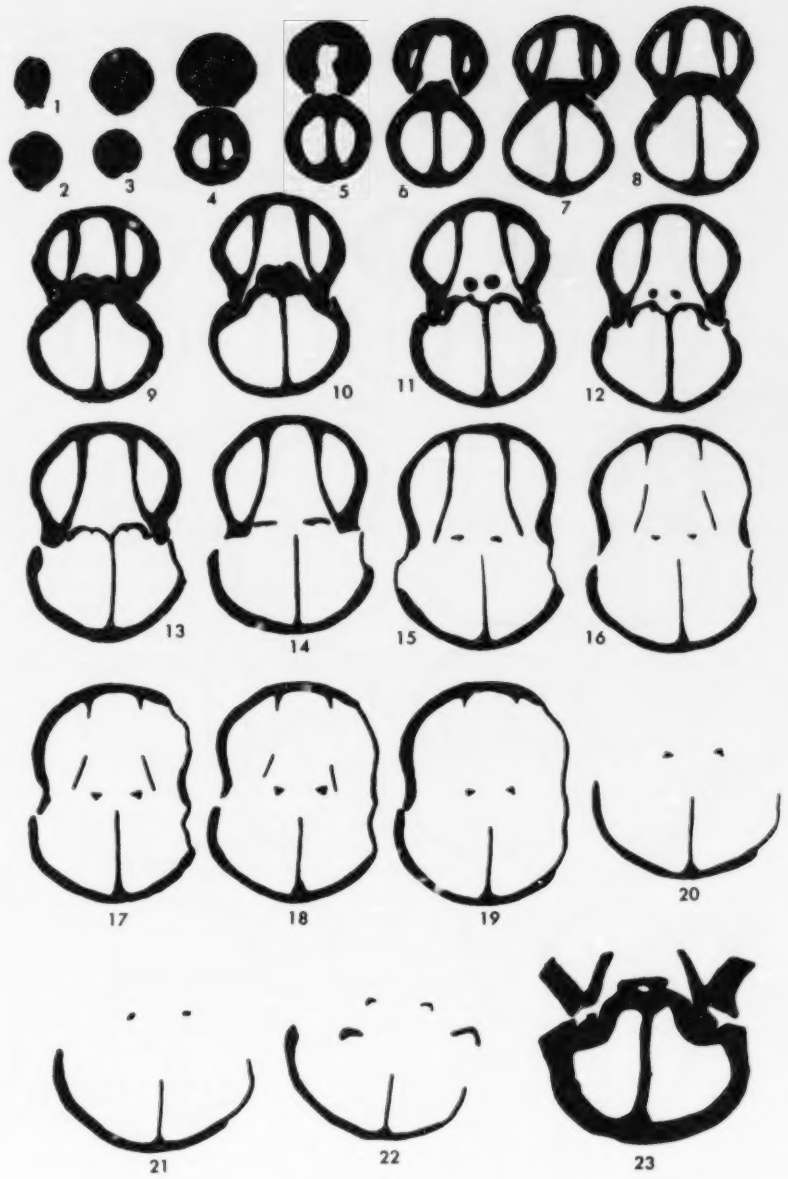
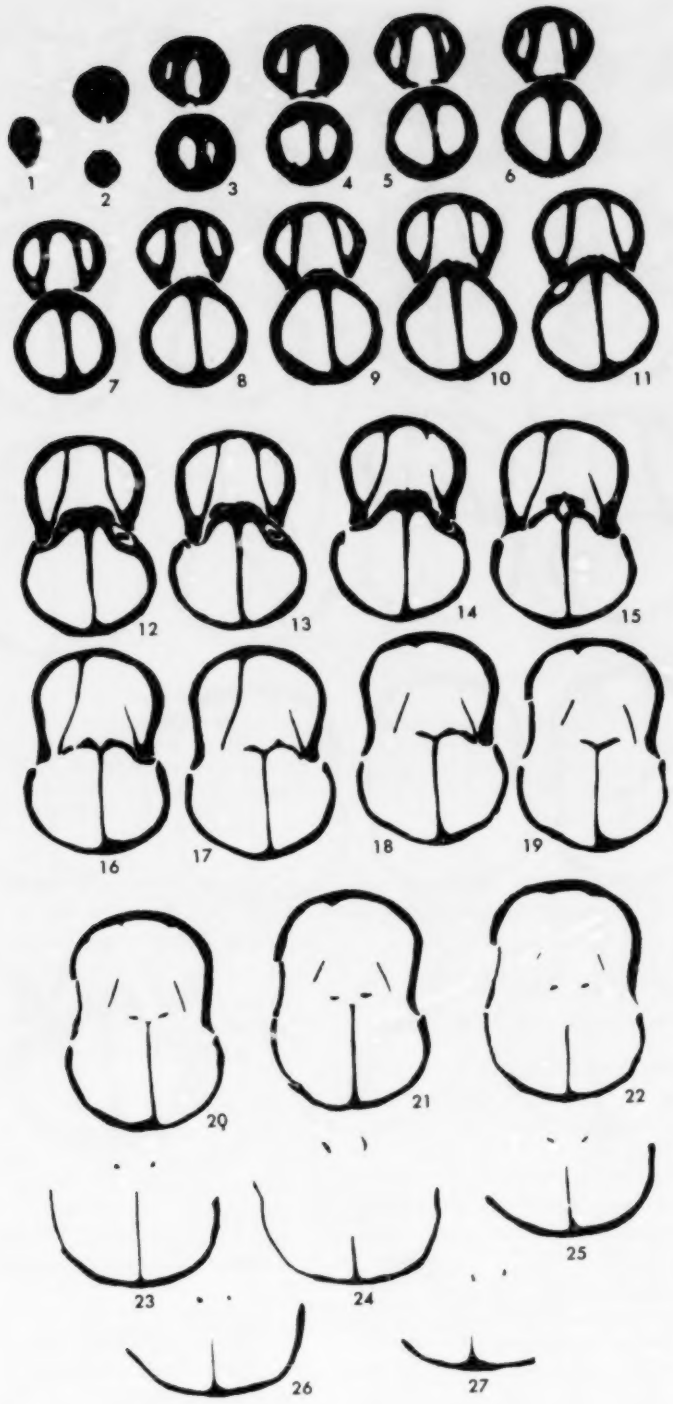


FIGURE 23.—*Heteromychus magificus*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.4(0.4); 2, 0.4(0.8); 3, 0.5(1.3); 4, 0.6(1.9); 5, 0.2(2.1); 6, 0.4(2.5); 7, 0.4(2.9); 8, 0.5(3.4); 9, 0.3(3.7); 10, 0.3(4.0); 11, 0.2(4.2); 12, 0.2(4.4); 13, 0.2(4.6); 14, 0.3(4.9); 15, 0.4(5.3); 16, 0.3(5.6); 17, 0.2(5.8); 18; 0.3(6.1); 19, 0.4(6.5); 20, 0.8(7.3); 21, 0.8(8.1); 22, 0.3(8.4). Dorsal septum disappears at 11.2 mm; approximately ×1.5; length 27.2 mm; USNM 380655; Locality KK9-112. 23, Dorsal valve sectioned at plane of symmetry, showing cardinal process, ×2; USNM 380288c; Locality KK9-112.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profile. Fold originating at midvalve, marked medially by narrow shallow sulcus.

Interior as described for genus.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; + indicates that measurement is estimated.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380576	40.5+	37.4+	35.0	33.0	72	19.0
390693a	27.8	26.7	26.0	25.0	64	13.5

OCCURRENCE.—Dhruma Formation (*Dhrumaites* Zone): KK9-96, -96–97, 111. (Atash Member): S1148, S1296, KK9-112, -112–114, -113, -114.

TYPES.—Holotype: USNM 380576. Paratypes: USNM 380288a–d, 380653, 380655, 380693a–c.

DISCUSSION.—This species most closely resembles *Conarosia sphenoidea*, new species, equalling that species in size although differing in its anterior quadrate folding, presence of a cardinal process and differently formed septalium.

Heteromychus? species

DESCRIPTION.—A very poorly preserved and badly crushed specimen with fine flat costellae separated by thin striae suggests an enormous species of *Heteromychus*. The length of the specimen cannot be measured because of the anterior to posterior crushing. This may emphasize the width to some extent, which is 59 mm. The specimen in perfect condition would have been enormous for a rhynchonellid. There is a long median septum measuring 25 mm. This is possibly a large specimen of *Heteromychus magnificus* that occurs in the Atash Member.

OCCURRENCE.—Middle Dhruma Formation (*Dhrumaites* Zone): KK9-111.

SPECIMEN EXAMINED.—USNM 380429 (not figured).

Kallirhynchia Buckman, 1917

Kallirhynchia arabica, new species

FIGURE 25; PLATE 10: FIGURES 56–71

DIAGNOSIS.—*Kallirhynchia* with numerous costae in fold and on sulcus.

DESCRIPTION.—Medium, subtriangular, maximum width just anterior to midvalve. Dorsal valve deeper than ventral valve. Sides rounded, apical angle variable. Anterior commissure uniplicate. Beak narrow, short, suberect; foramen large, subelliptical; deltidial plates small with marginal rims, disjunct. Costae numerous, crowded, narrowly rounded, about 24.

Ventral valve flatly convex in lateral profile, nearly flat in anterior view with wide median depression. Median region gently convex. Sulcus originating at midvalve, shallow, occupied by 4 to 8 costae. Tongue fairly long. Flanks, narrow, rounded, elevated above fold at anterior.

Dorsal valve fairly strongly convex in lateral view, strongly, roundly domed in anterior view. Umbonal and median regions swollen. Fold of 5-7 costae originating at midvalve, slightly elevated in anterior half. Flanks, swollen, steep.

Interior: Ventral valve with long, widely divergent dental plates extending for about 1/4 valve surface length. Pedicle collar short.

Dorsal valve interior with fairly large septalium supported by long, low septum extending for about 1/3 valve length. Crura radulifer curved short, crescentic in section with convexity posteroventrad. The crura of *Kallirhynchia* were originally described by Muir-Wood (1934:526, 1936:14) as calcarifer. Sections made by Laurin (1984:281–291 and discussion on page 381) prove the crura to be radulifer. Laurin has redefined the genus with radulifer crura. The crura of *K. arabica* are of radulifer type.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380239a	20.0	16.4	20.0	14.2	102	10.0
380239b	19.0	15.8	18.7	13.0	88	9.0
380365a	17.7	15.0	19.0	13.0	107	10.7
380365b	17.8	15.0	17.0	12.4	93	10.0
380446a	20.9	17.4	21.7	14.7	105	12.3
380446b	18.8	16.0	18.7	13.4	105	9.0
380446c	19.7	16.0	18.7	12.8	104	10.0
380446d	19.6	16.7	21.8	13.2	108	9.6
380446e	19.6	16.5	18.7	14.0	83	9.6
380446f	20.0	17.0	20.0	15.0	89	9.0
380446g	18.6	14.3	18.2	14.4	82	9.0

OCCURRENCE.—Dhruma Formation (*Tulites* Zone): S1191. Tuwaiq Mountain Formation: S1674.

TYPES.—Holotype: USNM 380239a. Paratypes: 380239b, 380365a,b, 380446a–g, 400916.

DISCUSSION.—This species is suggestive of *Kallirhynchia* cf. *obsoleta* (Weir 1929, pl. 3: fig. 24a,b), but the African form from the Daua Limestone is not so thick as the Saudi Arabian species and is somewhat smaller. It is the same size as *K. amoena* Buckman 1917, differing in having a deeper sulcus and more prominent fold. *K. yaxleyensis* (Davidson, 1878:206,

FIGURE 24.—*Heteromychus magnificus*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.5(1.1); 3, 1.0(2.1); 4, 0.3(2.4); 5, 0.3(2.7); 6, 0.1(2.8); 7, 0.3(3.1); 8, 0.3(3.4); 9, 0.2(3.6); 10, 0.1(3.7); 11, 0.4(4.1); 12, 0.5(4.6); 13, 0.3(4.9); 14, 0.2(5.1); 15, 0.3(5.4); 16, 0.2(5.6); 17, 0.3(5.9); 18, 0.2(6.1); 19, 0.1(6.2); 20, 0.3(6.5); 21, 0.1(6.6); 22, 0.5(7.1); 23, 1.1(8.2); 24, 1.2(8.4); 25, 0.1(9.5); 26, 0.7(10.2); 27, 0.5(10.7). Approximately ×1.5; length 24.4 mm; USNM 380653; locality unknown.

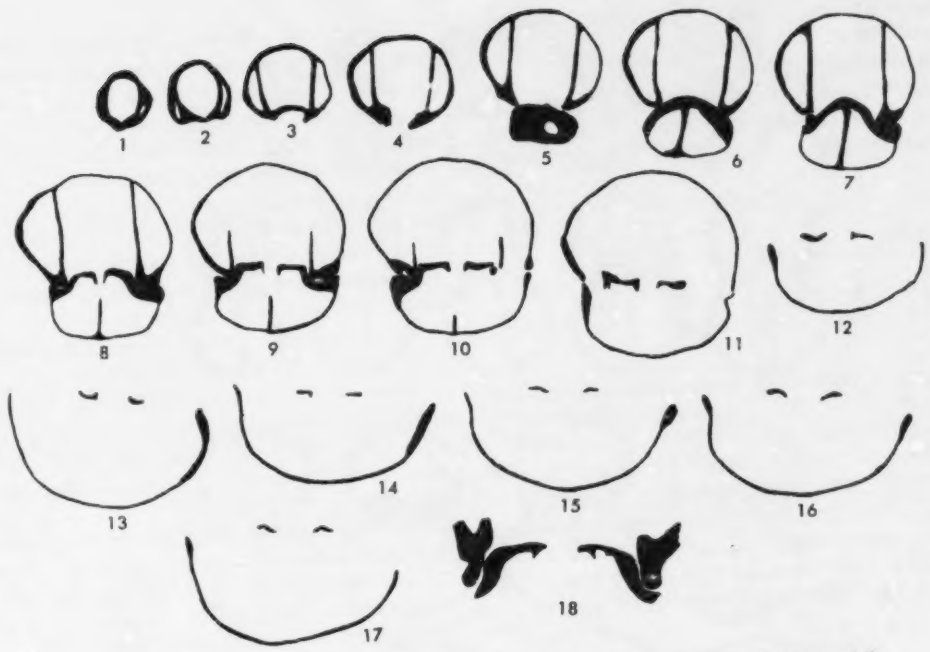

FIGURE 25.—*Kallirhynchia arabica*, new species (numbers show distance in mm between sections and (in parentheses) distance from the beak): 1, 0.7(0.7); 2, 0.4(1.1); 3, 0.7(1.8); 4, 1.1(2.9), 5, 0.3(3.2); 6, 0.2(3.4); 7, 0.4(3.8); 8, 0.2(4.0); 9, 0.2(4.2); 10, 0.2(4.4); 11, 0.3(4.7); 12, 0.2(4.9); 13, 0.6(5.5); 14, 0.2(5.7); 15, 0.1(5.8); 16, 0.1(5.9); 17, 0.2(6.1). Approximately ×2. 18, Enlarged detail of section 9, approximately ×4; length 16.1 mm; USNM 400916; Locality S1674.

pl. 37: fig. 23) is more strongly costate than *K. arabica* and with wider, subdued fold and sulcus.

Kallirhynchia dispar, new species

PLATE 11: FIGURES 22–26

DIAGNOSIS.—Medium sized subtriangular *Kallirhynchia* with four costae in sulcus.

DESCRIPTION.—Medium, subtriangular, maximum width anterior to midvalve. Valves strongly unequal in depth, dorsal valve deepest. Anterior margin nearly straight, sides narrowly rounded, apex nearly a right angle. Lateral commissure straight; anterior commissure widely uniplicate. Beak narrow, pointed, nearly straight. Foramen fairly large, longitudinally oval; deltidial plates narrow, disjunct with raised margins. Costae strong, subangular, separated by grooves narrower than costae; about 21 costae.

Ventral valve flatly convex in side view, broadly concave in anterior view. Sulcus starting at about midvalve, widening, deepening anteriorly, occupied by four costae. Tongue long, anteriorly serrate.

Dorsal valve fairly strongly convex in side view, strongly domed with sloping sides in anterior profile. Median region swollen. Fold originating at midvalve, well elevated above convex flanks at anterior. Fold occupied by 5 costae.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380229a	19.5	16.6	20.8	13.5	88	10.4
380229b	18.5	16.0	19.4	12.5	88	9.3

OCCURRENCE.—Dhruma Formation (*Tulites* Zone): S1738; (Zone not placed): S1644.

TYPES.—Holotype: USNM 380229a. Paratype: USNM 380229b.

DISCUSSION.—This species is most like *Kallirhynchia arabica*, new species, differing in larger size, less numerous, stronger costae, narrower beak, and stronger fold and sulcus.

Kallirhynchia obesa, new species

PLATE 17: FIGURES 43–45

DIAGNOSIS.—Narrowly elongate, strongly convex *Kallirhynchia*.

DESCRIPTION.—Small, roundly elongate oval; dorsal valve deeper than ventral valve. Anterior rounded, sides broadly rounded; apical angle obtuse. Lateral commissure straight; anterior commissure strongly uniplicate. Beak small, low, close to dorsal valve umbone. Deltidial plates disjunct. Costae narrowly rounded, about 30, closely crowded, separated by striae narrower than costae.

Ventral valve gently, evenly convex in side view, flatly convex with short precipitous sides in anterior view. Median and umbonal regions moderately swollen. Sulcus poorly defined, wide, with 7 costae. Tongue long, at right angle to plane of commissure.

Dorsal valve fairly strongly convex in side view, narrowly, strongly domed in anterior view with long precipitous sides. Fold indistinct with 8 costae. Anterior third geniculated toward commissure.

Interiors not seen.

MEASUREMENTS (in mm).—USNM 380564: length 19.5, dorsal valve length 17.2, width 17.7, thickness 17.4, apical angle 97°, fold width 9.4.

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): KK8A-58.

TYPE.—Holotype: USNM 380564.

DISCUSSION.—This species differs from *K. orbicularis*, new species, in its narrower and more obese form. It is suggestive of *K. exalta* Buckman (1917, pl. 15: fig. 21a–d) having the flattened anterior and long tongue but differing in smaller size and rounded sides.

Kallirhynchia orbicularis, new species

PLATE 11: FIGURES 6–10

DIAGNOSIS.—Round *Kallirhynchia* with length and width nearly equal.

DESCRIPTION.—Medium, roundly triangular. Maximum width about midvalve. Sides and anterior rounded, apical angle obtuse. Anterior commissure broadly uniplicate. Beak, short, low, suberect. Foramen large; deltidial plates conjunct. Costae numerous, rounded, crowded, 21 to 27.

Ventral valve gently convex in side view, broadly, flatly domed in anterior profile. Valve moderately swollen. Sulcus poorly defined starting near midvalve, slightly depressed below narrow, rounded flanks at anterior, with 6 costae. Tongue short, broadly rounded.

Dorsal valve fairly strongly convex in side view, more convex than ventral valve; moderately, broadly domed with steep rounded sides in anterior profile. Valve strongly swollen. Fold poorly developed, barely visible above flanks in anterior half, with 7 costae.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380522a	18.6	16.0	18.9	13.6	98	12.3
380522b	19.0	16.4	18.9	13.2	98	10.6

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): S1191.

TYPES.—Holotype: USNM 380522a. Paratype: USNM 380522b.

DISCUSSION.—This species is smaller, rounder, and thicker than *K. arabica*, new species. It is similar to *K. superba* Buckman (1917, pl. 15: fig. 6a–c) differing in rounder, wider form and less deflected tongue. *Kallirhynchia deliciosa* Buckman (1917, pl. 15: fig. 15a–c) resembles the Saudi Arabian form, which, however, is more elongate with larger beak and more posteriorly directed tongue.

Kutchirhynchia Buckman, 1917

Kutchirhynchia arabica, new species

FIGURE 26; PLATE 11: FIGURES 27–36

DIAGNOSIS.—Medium size *Kutchirhynchia* with crowded strong costae.

Large, pentagonal, wider than long, dorsal valve more convex than ventral valve. Maximum width at midvalve. Apical angle obtuse. Anterior commissure broadly, arcuately uniplicate. Beak short; foramen large; deltidial plates disjunct to conjunct, with elevated margin. Costae numerous, rounded to subangular with interspaces narrower than costae, about 27 costae.

Ventral valve, flatly to gently convex in side view, nearly flat in anterior profile. Median region gently swollen. Sulcus broad, shallow, beginning posterior to midvalve, occupied by 6 to 9 costae. Flanks barely elevated above sulcus at anterior. Tongue fairly long, broadly rounded.

Dorsal valve fairly strongly convex in side view, broadly and strongly domed in anterior profile. Median region swollen. Fold originating just posterior of midvalve, slightly elevated above flanks, occupied by 7 to 9 costae; flanks convex.

Interior: Ventral valve with long divergent dental plates extending for 1/4 surface length. Dorsal valve with short, small, septalium; thin, long median septum not reaching midvalve.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380271a	25.5	21.7	28.2	18.5	110	16.0
380271b	22.8	19.5	24.3	15.4	93	13.2
380271c	22.6	19.0	24.6	17.0	106	14.6
380271d	22.3	19.5	24.0	16.4	108	16.4

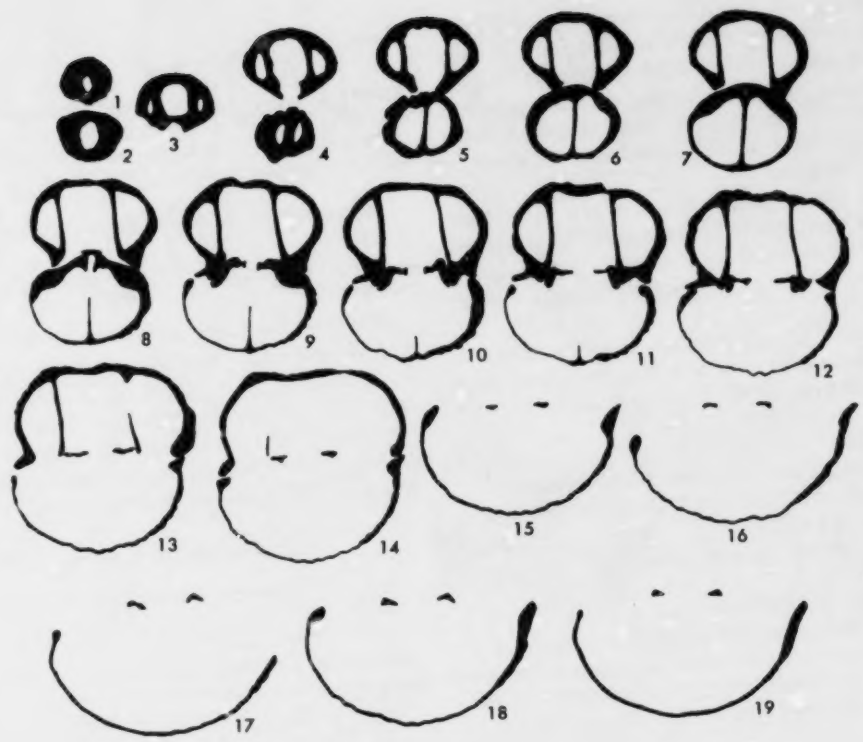

FIGURE 26.—*Kutchirhynchia arabica*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 1.0(1.0); 2, 0.4(1.4); 3, 0.3(1.7); 4, 0.5(2.2); 5, 0.2(2.4); 6, 0.3(2.7); 7, 0.4(3.1); 8, 0.3(3.4); 9, 0.3(3.7); 10, 0.2(3.9), 11, 0.2(4.1); 12, 0.3(4.4), 13, 0.3(4.7); 14, 0.4(5.1); 15, 0.7(5.8); 16, 0.3(6.1); 17, 0.2(6.3); 18, 0.3(6.6); 19, 0.3(6.9). All structures gone after 6.9 mm; approximately ×2; length 21.5 mm; USNM 380666; Locality S1191. 20, USNM 380271e cut to show septalium, ×5; Locality S1191.

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): S1191.

TYPES.—Holotype: USNM 380271a. Paratypes: USNM 380271b–e, 380666.

DISCUSSION.—This brachiopod conforms to *Kutchirhynchia* in the details of its exterior, having a wide fold and sulcus with numerous costae. Little is known of the interior of specimens from India. A few specimens from Saudi Arabia are silicified but yielded poor interiors. Nevertheless, dental plates and septum were revealed and one crus proved to be of radulifer type.

Unfortunately most of the specimens from S1191 are badly crushed and silicified and yielded only about a dozen useful specimens.

This species differs from *Kutchirhynchia kutchensis* (Kitchin, 1900) in its smaller size, more crowded costae, and smaller apical angle.

The specimens from Saudi Arabia do not conform internally to those depicted by Laurin (1984:376–377) who uses Buckman's (1917) *K. idonea* as a reference rather than the Indian species, *K. kutchensis*, which is the designated type. The French specimens according to Laurin's sections of *K. obsoleta* (J. Sowerby, 1815), *K. morieri* (Davidson, 1852), and others lack a median septum or have a low ridge rather than a

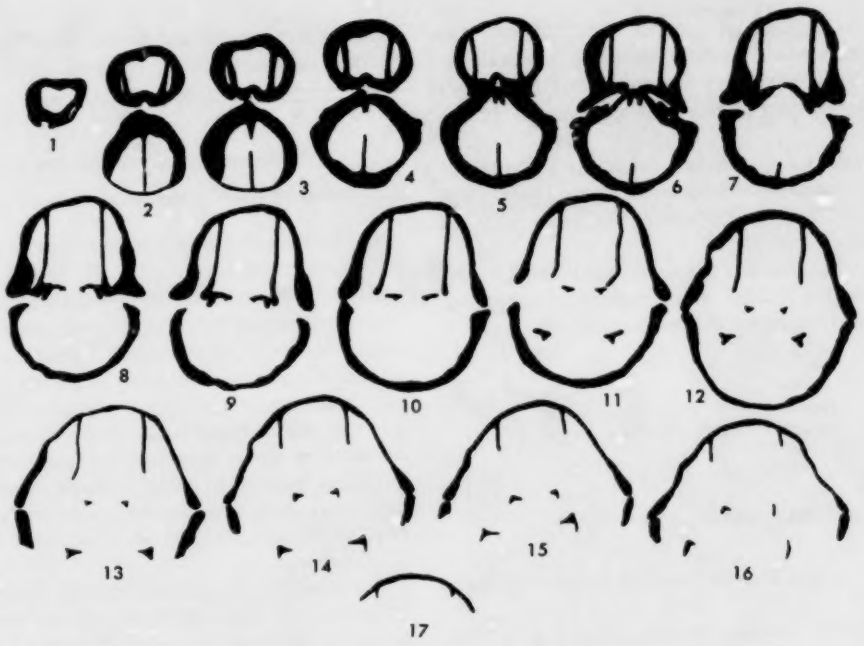

FIGURE 27.—*Lirellarina costellata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.3(0.9); 3, 0.3(1.2); 4, 0.2(1.4); 5, 0.3(1.7); 6, 0.4(2.1); 7, 0.3(2.4); 8, 0.2(2.6); 9, 0.2(2.8); 10, 0.3(3.1); 11, 0.3(3.4); 12, 0.2(3.6); 13, 0.2(3.8); 14, 0.5(4.3); 15, 0.3(4.6); 16, 0.3(4.9); 17, 0.3(5.2). At 6.8 mm all trace of dental plates lost; approximately ×2; length 15.0 mm; USNM 380690; Locality S1677.

long high septum. The Saudi Arabian species has a long, high septum. The one specimen of *K. kutchensis* from India in the USNM collections (USNM 75997) shows a black line on the worn dorsal umbo indicating a fairly long median septum; its height, however, is not known.

Lirellarina, new genus

TYPE SPECIES.—*Lirellarina costellata*, new species.

DIAGNOSIS.—Medium size, subpentagonal, unequally biconvex with dorsal valve deeper and more convex than ventral valve. Strongly uniplicate. Costellate, with costellae bifurcating on umbones and flanks. Dental plates long, thin. Median septum long, septalium small; crural bases present, crura radulifer.

SPECIMENS STUDIED.—11.

GEOLOGICAL OCCURRENCE.—Bajocian.

ETYMOLOGY.—Latin *lirella* (small furrow and ridge).

DISCUSSION.—This genus suggests relationship to *Striirhynchia* Buckman, 1917. That genus is small and differently shaped than *Lirellarina*, which is widely oval and with very fine costellae. *Lirellarina* resembles *Caucasorhynchia* Dagis (1963:63), which has intercalated and bifurcated ribbing. The Russian genus, however, does not have a median septum and the dental plates are weakly developed, unlike *Lirellarina*, which has strong dental plates and a strong median septum.

Lirellarina costellata, new species

FIGURE 27; PLATE 11: FIGURES 43–55

DIAGNOSIS.—Subpentagonal outline, strong fold and sulcus, costellate exterior.

DESCRIPTION.—Medium, subpentagonal, valves unequal, dorsal valve more convex and deeper than ventral valve. Maximum width about midvalve, sides bulging. Posterolateral margins forming acute angle. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak low, suberect; foramen oval, hypothyridid; deltidial plates conjunct with marginal rims. Surface costellate, costellae numerous, 5 or 6 in 5 mm, about 45 total.

Ventral valve moderately convex in side view, slightly convex to flatly concave in anterior profile. Umbonal region strongly swollen, swelling continued anteriorly to midvalve where sulcus originates. Sulcus broad, shallow with 8-12 costellae; tongue long, flat, narrowly rounded at extremity.

Dorsal valve moderately convex in lateral profile, narrowly

to broadly, strongly domed in anterior view. Umbonal and median regions swollen, swelling extending anteriorly as narrow, rounded fold originating near midvalve. Fold strongly elevated in anterior third to fourth of valve length. Flanks swollen, steep.

Interior: Ventral valve with long dental plates. Delthyrial cavity with long myophragm, in some specimens. Dorsal valve interior with median septum extending for about 2/3 valve surface length, crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement from imperfect specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380241a	19.8	16.0	20.4	15.0	86	9.0
380241c	17.0	14.5	15.4	13.8	81	7.4
380241b	18.0	15.7	17.0	14.7	85	7.0?

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1677.

TYPES.—Holotype: USNM 380241c. Paratypes: USNM 380241a,b, 380636, 380690.

DISCUSSION.—No other rhynchonellid in the Saudi Arabian Jurassic is similar to *Lirellarina costellata*.

Nastosia, new genus

TYPE SPECIES.—*Nastosia coangustata*, new species.

DIAGNOSIS.—Roundly ovate, strongly costate rhynchonellids with long dental plates very closely positioned and nearly parallel. Foramen minute.

SPECIMENS STUDIED.—8.

GEOLOGICAL OCCURRENCE.—Bajocian.

ETYMOLOGY.—Greek *nastos* (pressed close), in allusion to the very narrow delthyrial chamber formed by the closely positioned dental plates.

DISCUSSION.—*Nastosia* is elongate oval, with all margins well rounded and fold and sulcus subdued, both of which are only visible at the anterior. The costae are strong and broad. The beak is erect and the deltidial plates disjunct with marginal rims. The foramen is small, elongate, a narrow slit.

Inside the ventral valve the dental plates are long, thin, close, and parallel, 1.5–2 mm apart near their anterior termination. Inside the dorsal valve the median septum is thin, persistent for fully a third the valve length. The septalium is long, thin. The hinge plates are flattish to convex posteriorly. They give way to crura at about the point of disappearance of the dental plates in section. The crura are radulifer.

Nastosia is somewhat suggestive of *Prionorhynchia* Buckman, 1917, which is strongly costate. It is wider and not oval like *Nastosia*. Furthermore, the interior details of *Nastosia* differ strongly from those of *Prionorhynchia*, which has a very short median septum and dental plates that are convergent ventrally, not parallel as in *Nastosia*. There appears to be no other rhynchonellid quite like this one.

Nastosia coangustata, new species

FIGURE 28; PLATE 11: FIGURES 37–42; PLATE 12: FIGURES 1–5

DIAGNOSIS.—Roundly ovate *Nastosia* with narrow delthyrial chamber.

DESCRIPTION.—Large, longitudinally roundly ovate; nearly equivalve, strongly biconvex. Sides rounded, anterior margin slightly nasute; apical angle acute. Lateral commissure straight; anterior commissure moderately uniplicate. Beak short, incurved; foramen very small, tubular; a narrow slit; deltidial plates disjunct with marginal rims. Costae strong, broad, rounded separated by narrow striae, numbering about 14.

Ventral valve fairly strongly convex in side view, broadly, moderately domed in anterior view. Median part strongly swollen. Sulcus poorly defined, occupied by three costae. Tongue short.

Dorsal valve with convexity slightly greater than that of the ventral valve in side view, doming in anterior view about equal to that of the ventral valve. Median region greatly swollen. Fold poorly defined, slightly raised above rounded flanks in anterior third. Fold with 4 costae.

Interior: Ventral valve with long closely crowded dental plates 1.5 to 2 mm apart.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement of imperfect specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380199a	25.5	23.2	22.5	21.0	84	12.0?
390199b	25.5	22.0	22.6	19.6	85	12.2
380279	21.8	19.2	19.5	18.4	78	9.8

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1409, S1679.

TYPES.—Holotype: USNM 380199b. Paratype: USNM 380199a, 380279, 380656.

DISCUSSION.—The nearest rhynchonellid externally like *Nastosia coangustata* is *Echyrosia costata*, new species. *Echyrosia costata*, however, has a more prominent fold and sulcus, is more triangular in outline, and has divergent dental plates.

Nastosia? convexa, new species

PLATE 17: FIGURES 38–42

DIAGNOSIS.—Elongate with strongly swollen dorsal valve and numerous narrowly rounded costae.

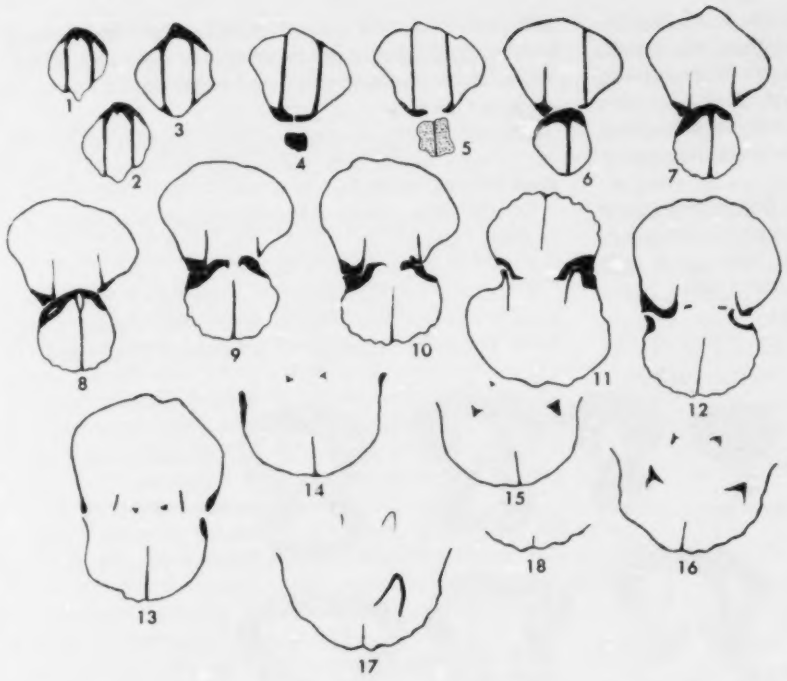

FIGURE 28.—*Nastosia coangustata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.5(0.5); 2, 0.9(1.4); 3, 0.4(1.8); 4, 0.8(2.6); 5, 0.2(2.8); 6, 0.5(3.3); 7, 0.3(3.6); 8, (= (3.7); 9, 0.3(4.0); 10, 0.3(4.3); 11, 0.2(4.5); 12, 0.3(4.8); 13, 0.1(4.9); 14, 0.4(5.3); 15, 0.4(5.7): 16, 0.3(6.0); 17, 0.2(6.2); 18, 0.6(6.8). Dorsal septum disappears at 7.8 mm; approximately ×2; length 22.1 mm; USNM 380656; Locality S1679.

DESCRIPTION.—Large, elongate oval, strongly biconvex. Sides gently rounded, anterior broadly rounded, apical angle acute. Lateral commissure straight, anterior commissure strongly uniplicate. Beak low, erect, close to dorsal umbone, hypothyridid. Deltidial plates thick, disjunct. Costae narrowly rounded, separated by striae wider than costae; about 19.

Ventral valve gently convex with greatest convexity at umbo in side view; flatly, broadly domed with short steep sides in anterior profile. Sulcus shallow, beginning near midvalve, forming short tongue. Four costae in sulcus.

Dorsal valve fairly strongly convex in side view, narrowly domed with long steep sides in anterior view. Fold low, convex, originating posterior of midvalve, with 5 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380398: length 23.7, dorsal valve length 20.0, width 19.9, thickness 19.4, apical angle 67°, fold width 10.0.

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1409.

TYPE.—Holotype: USNM 380398.

DISCUSSION.—This species differs from *Nastosia coangustata*, new species, in its narrower form, stronger folding, narrower, more numerous costae and wider angle to dental plates (seen from outside). The latter fact is the reason for querying the generic designation.

Pycnoria, new genus

TYPE SPECIES.—*Pycnoria magna*, new species.

DIAGNOSIS.—Medium to large, thick-shelled, subtriangular to subpentagonal; beak small, low, erect to incurved. Foramen small, hypothyridid. Deltidial plates conjunct, rimmed. Strongly costate. Dental plates long, thick. Septalium small; median ridge, low, thick, moderately long. Crura radulifer.

SPECIMENS STUDIED.—100.

GEOLOGICAL OCCURRENCE.—Bathonian to Callovian.

ETYMOLOGY.—Greek *pycnos* (thick).

DISCUSSION.—The interior details of this genus are similar to those of *Burmirhynchia*. The growth habit, shape, and ornamentation, however, are different from *Burmirhynchia*. The latter as depicted by the numerous species from Burma are usually somewhat elongate, usually narrow, and mostly with poorly developed folding. *Pycnoria*, on the other hand is strongly costate, with high fold and deep sulcus. In these features *Pycnoria* is like some strongly costate, strongly folded forms recently referred to *Burmirhynchia* by Laurin (1984), such as *B. decorata* (Schlotheim), *B. quadricristata* (Rollier) and *B. turgida turgida* Buckman. All these forms, together with *Pycnoria magna* are entirely unlike typical *Burmirhynchia* as shown by *B. decorticata*, *B. rostrata*, and *B. angustata*, all new species. *Pycnoria* is best developed in the Upper Dhruma Formation.

Pycnoria compacta, new species

PLATE 12: FIGURES 6–10

DIAGNOSIS.—Small *Pycnoria* with few sharply angular costae.

DESCRIPTION.—Small, longer than wide, subtriangular. Maximum width at anterior. Anterior margin nearly straight, anterolateral extremities rounded; apical angle slightly obtuse. Anterior commissure strongly uniplicate. Beak very low, rounded, erect; foramen small, hypothyridid; deltidial plates, poorly preserved disjunct. Strongly costate, costae strong, sharply angular, numbering 12.

Ventral valve flatly convex in side view, fairly deeply sulcate in anterior profile. Umbonal region moderately swollen; sulcus originating on umbo deepening, widening anteriorly to form long serrate tongue. Sulcus occupied by 2 strong costae, deeply depressed below narrow, precipitous flanks.

Dorsal valve gently convex in side view, narrow domed, with precipitous sides in anterior profile. Valve fairly strongly swollen. Fold beginning at umbo narrow, moderately elevated above narrow flanks, occupied by 3 strong costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380453: length 19.0, dorsal valve length 16.8, width 18.0, thickness 16.3, apical angle 94°, fold width 9.2.

OCCURRENCE.—Dhruma Formation (Zone not placed): base of slope, Astro 61.

TYPE.—Holotype: USNM 380453.

DISCUSSION.—This species is smaller than *P. magna*, new species, and narrower, with stronger more angular, though fewer costae. It resembles *"Burmirhynchia" thierachensis*

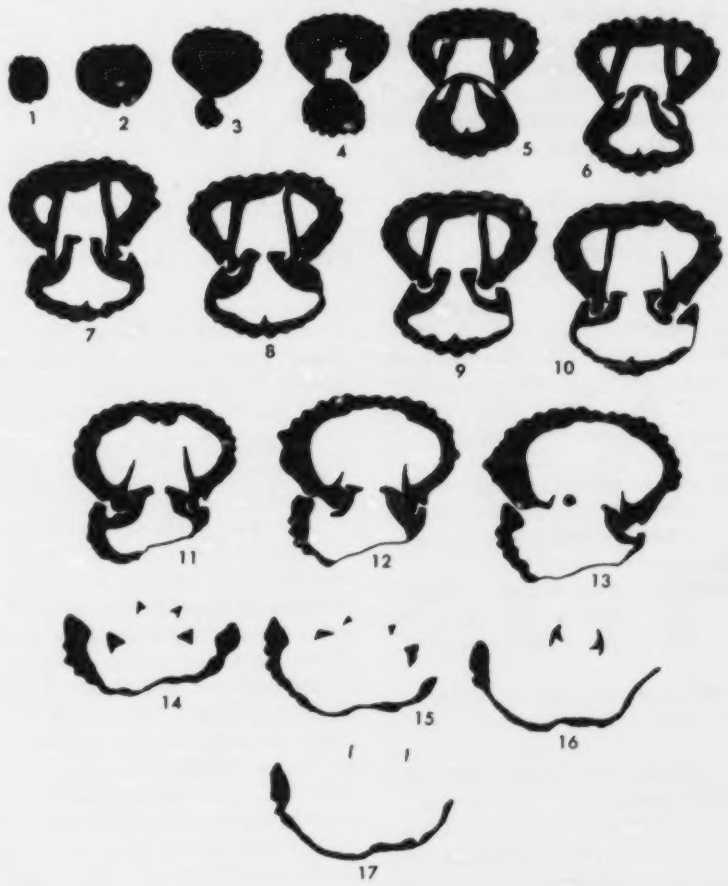

FIGURE 29.—*Pycnoria magna*, new species (numbers 1–10 show distance in mm between sections and (in parentheses) distance from beak): 1, 1.6(1.6); 2, 0.8(2.4); 3, 0.7(3.1); 4, 0.3(3.4); 5, 0.3(3.7); 6, 0.3(4.0); 7, 0.3(4.3); 8, 0.3(4.6); 9, 0.2(4.8); 10, 0.3(5.1). All lost after section 10; approximately ×2; length of dorsal valve 18.8 mm; USNM 380648; Locality KK9-112. (Numbers 11–17 show distance in mm between sections and (in parentheses) distance from beak of imperfect specimen with beak region missing but showing an initial section like that of section 10 above): 11, ?; 12, 0.5(0.5); 13, 0.4(0.9); 14, 0.3(1.2); 15, 0.6(1.8); 16, 0.3(2.1); 17, 0.5(2.6); Approximately ×2; length uncertain; USNM 380678; Locality KK9-112.

(Fischer, 1964) a late Bathonian form as depicted by Laurin (1984:3, figs. 5, 8). *Pycnoria compacta* differs from that species in having more costae in the sulcus.

Pycnoria magna, new species

FIGURES 29, 30; PLATE 12: FIGURES 11–36, PLATE 18: FIGURES 26–36

DIAGNOSIS.—Large, wide, strongly costate.

DESCRIPTION.—Medium to large, rotund, length and width almost equal to or slightly wider than long. Sides and anterior rounded, apical angle obtuse. Maximum width slightly anterior to midvalve. Dorsal valve more convex and deeper than ventral valve. Lateral commissure straight; anterior commissure narrowly uniplicate. Beak short, narrow, erect to incurved and pressed onto the dorsal umbone. Beak ridges strong. Foramen small, hypothyridid; deltidial plates small with marginal rims, conjunct or disjunct. Costate, costae subangular, strong, crossed by very fine concentric lines, 13–17 costae.

Ventral valve flatly convex in side view, flatly convex, and medially concave in anterior profile. Umbonal region flatly convex with sulcus originating just anterior to umbone, sulcus widening and deepening anteriorly, attaining moderate depth at anterior, occupied by 2 to 4 costae, more commonly 2. Flanks strongly elevated above sulcus anteriorly. Flanks narrow, rounded, steep.

Dorsal valve strongly, evenly convex in lateral profile, strongly domed in anterior view with fold gently elevated above steep, rounded flanks. Umbonal region costate, somewhat swollen. Fold, narrow, prominent anteriorly, originating just anterior of umbone, occupying 1/2 valve width, with 3 to 5 costae, usually 3.

Interior: Both valves of large specimens thickened by adventitious shell tending to obscure dental plates and median septum. Ventral valve interior with pedicle collar; dental plates and teeth thick, moderately long.

Dorsal valve interior with moderately long low median ridge; septalium small. Sockets corrugated. Outer hinge plates narrow, crural bases not developed. Crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380207	21.0	18.4	21.7	18.0	112	10.7
380215a	24.0	20.7	24.2	18.2	96	12.0
380216	18.8	16.3	19.0	17.8	93	7.3
380565a	21.8	19.5	25.8	19.2	111	11.7
380603	24.2	21.8	24.4	21.0	111	10.3
380604	21.8	20.0	23.0	19.0	103	12.5

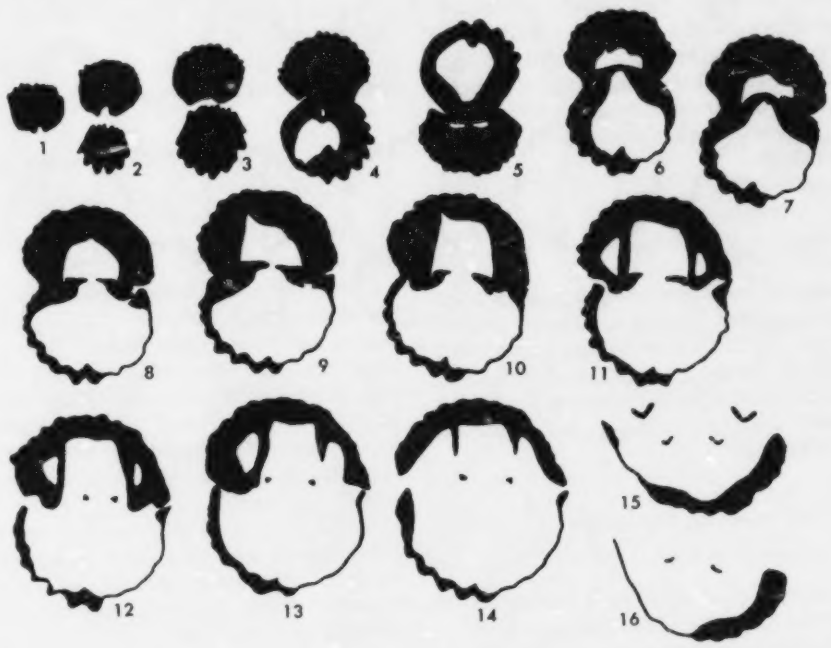

FIGURE 30.—*Pycnoria magna*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 1.1(1.1); 2, 0.3(1.4); 3, 0.4(1.8); 4, 0.5(2.3); 5, 0.4(2.7); 6, 0.2(2.9); 7, 0.4(3.3); 8, 0.6(3.9); 9, 0.2(4.1); 10, 0.1(4.2); 11, 0.4(4.6); 12, 0.1(4.7); 13, 0.4(5.1); 14, 0.1(5.2); 15, 0.9(6.1); 16, 0.4(6.5). Approximately ×1.7; length 16.2 mm; USNM 380649; Locality KK9-22.5.

OCCURRENCE.—Dhruma Formation (*Micromphalites* Zone): KK9-20–24, -21, -21.5, -22.5, -52.5, -54, -56–57. (*Dhrumaites* Zone): S1005, S1007, S1425, S1436, KK9-90; (Atash Member): KK9-112, -112–114, -112–115, -113-115; (Hisyan Member): S1444, (Zone not placed): S1179, S1652, S1755.

TYPES.—Holotype: USNM 380215a. Paratypes: 380207, 380215b, 380216, 380378, 380394, 380565a,b, 380603, 380604, 380648, 380649, 380678.

DISCUSSION.—Specimens from the *Micromphalites* Zone tend to be somewhat smaller than those from the Upper Dhruma Formation. There are however, in the lower zones a few specimens that attain the large size of those of the Upper Dhruma.

The compact, solid form of this species is distinctive and separates it from species of *Daghanirhynchia* and *Somalirhynchia*. It differs from *Globirhynchia triangulata*, new species, in its stronger costation, narrower fold, and deeper sulcus. It is larger and wider, with stronger costae than the species of *Burmirhynchia* described herein. It resembles "*Burmirhynchia*" *turgida turgida* as illustrated by Laurin (1984, pl. 6: figs. 9, 11) differing in narrower fold and sulcus, usually with only 2 costae in the sulcus.

Schizoria, new genus

TYPE SPECIES.—*Schizoria elongata*, new species.

DIAGNOSIS.—Small to medium, subtriangular, subpentagonal to subcircular. Dorsal valve more convex than ventral valve. Uniplicate. Beak suberect to strongly incurved; foramen small, tubular, hypothyridid; deltidial plates disjunct. Costate, with costae bifurcated and intercalated, especially on the umbones. Dental plates long; median septum long, septalium small, short, crura radulifer.

SPECIMENS STUDIED.—89.

GEOLOGICAL OCCURRENCE.—Bajocian.

ETYMOLOGY.—Greek *schizos* (split), in allusion to the bifurcation of costae.

DISCUSSION.—Jurassic rhynchonellids with bifurcated and intercalated costae are unusual. Few are noted in the Treatise on Paleontology (Ager, 1965). *Caucasirhynchia* (Dagis, 1963) resembles *Schizoria* in having bifurcated and intercalated costae. It is not provided with a median septum and the dental plates are only weakly developed, conditions quite unlike the structure of *Schizoria*.

Schizoria costellata, new species

PLATE 13: FIGURES 37-45, PLATE 15: FIGURE 24

DIAGNOSIS.—*Schizoria* of moderate size, fine costae or costellae, and numerous intercalations and bifurcations.

DESCRIPTION.—Medium size for the genus, subpentagonal, maximum width slightly anterior of midvalve. Sides and anterior rounded. Apical angle acute. Lateral commissure straight; anterior commissure uniplicate. Beak fairly long, narrow; foramen small, hypothyridid; deltidial plates thick with marginal rim, disjunct. Costae thin, subangular, crowded, separated by striae narrower than costae. Bifurcation and intercalation frequent; about 30 costae.

Ventral valve moderately convex in side view, forming low steep sided dome in anterior profile. Median region swollen, anterior flattened. Sulcus visible at anterior third, shallow with 7 costae. Tongue short, rounded at extremity.

Dorsal valve fairly strongly convex in side view; moderately domed in anterior view. Median region greatly swollen. Fold visible only at anterior third, with 8 costae.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates no measurement could be taken from incomplete specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380242a	16.0	13.8	14.6	12.0	78	7.0
380242b	15.8	13.7	13.3?	12.2	83	?

OCCURRENCE.—Lower Dhruma Formation (between *Dorsetensia* and *Ermoceras* zones): S1057; (*Ermoceras* Zone): S1409.

TYPES.—Holotype: USNM 380242a. Paratype: USNM 380242b, 380301.

DISCUSSION.—This species is distinguished from all other schizorias by its finely costate surface.

Schizoria dividicostata, new species

PLATE 13: FIGURES 1–13

DIAGNOSIS.—Fairly large for genus, subpentagonal, moderately biconvex *Schizoria*.

DESCRIPTION.—Medium, subpentagonal, longer than wide. Maximum width near midvalve. Dorsal valve deeper and more convex than ventral valve. Anterior margin broadly rounded, often subnasute; sides somewhat narrowly rounded. Apical angle acute. Lateral commissure oblique; anterior commissure arcuately uniplicate. Beak short, suberect; foramen small, hypothyridid; deltidial plates disjunct. Costae narrowly rounded. Intercalations and bifurcations in 2 generations, about 27 costae.

Ventral valve moderately convex in side view, broadly and gently convex with steep sides in anterior profile. Median region swollen. Sulcus shallow, wide originating at about midvalve, slightly depressed below flanks in anterior third, occupied by 3 to 6 costae.

Dorsal valve gently convex in side view, broadly domed with moderately sloping sides in anterior profile. Median region swollen. Fold low, originating at about midvalve, elevated at anterior quarter to half.

Interior: Ventral valve with diverging dental plates extending for one-third valve length. Dorsal valve with long median septum and small, short septalium.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate estimated measurements from imperfect specimens.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380249a	16.4	14.2	14.6	10.4	82	6.4
380249b	15.2	13.4	13.0	10.5?	78	6.5
380349c	17.7	14.7	15.9	11.4?	86	9.0
380598a	16.7	14.7	14.1	11.4?	83	8.0
380598b	15.4	13.4	13.2	10.0?	84	7.0

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1677.

TYPES.—Holotype: USNM 380249a. Paratypes: USNM 380249b,c, 380391, 380598a–c.

DISCUSSION.—This species is large, of about the same size as *S. secta*, new species, from which it differs in its wider anterior, less inflated valves and narrower more numerous costae. *Schizoria* species 2 and *S. intercalata*, new species, are smaller, differently shaped species than *S. dividicostata*.

Schizoria elongata, new species

FIGURE 31; PLATE 14: FIGURES 17–27

DIAGNOSIS.—Narrowly elongate oval *Schizoria*.

DESCRIPTION.—Small, elongate oval, maximum width anterior of midvalve. Dorsal valve deeper and more convex than ventral valve; sides rounded, anterior margin narrowly rounded; apical angle acute. lateral commissure straight; anterior commissure narrowly uniplicate. Beak long, narrow, incurved; foramen small, tubular, hypothyridid; deltidial plates thick, disjunct. Costae subangular, crowded, bifurcated and intercalated on umbones, about 24.

Ventral valve moderately convex in lateral view, moderately domed in anterior profile. Umbonal region swollen; median

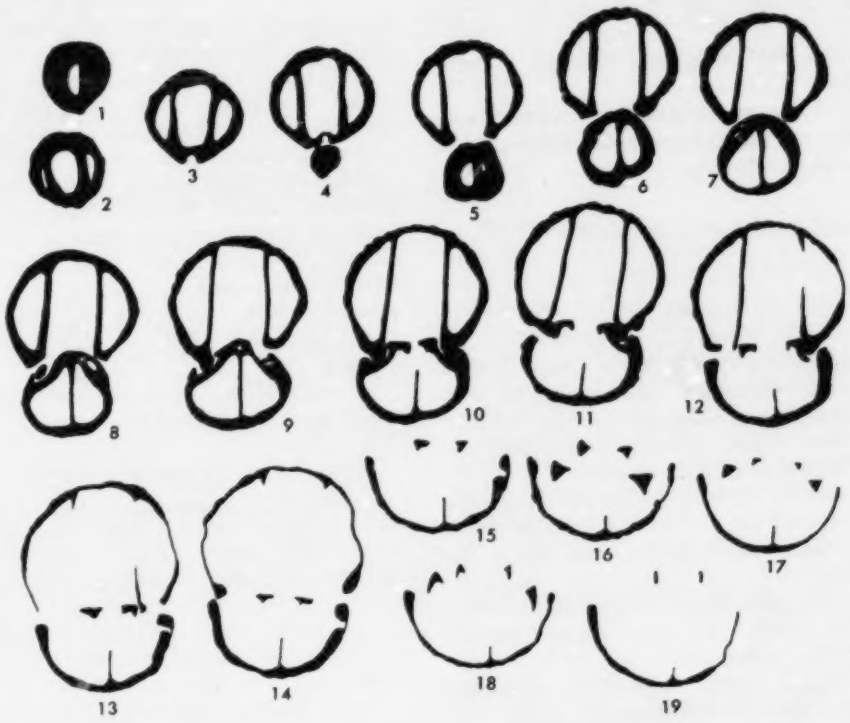

FIGURE 31.—*Schizoria elongata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 1.7(1.7); 2, 0.8(2.5); 3, 0.4(2.9); 4, 0.4(3.3); 5, 0.3(3.6); 6, 0.2(3.8); 7, 0.3(4.1); 8, 0.1(4.2); 9, 0.2(4.4), 10, 0.4(4.8); 11, 0.2(5.0); 12, 0.2(5.2); 13, 0.2(5.4); 14, 0.3(5.7); 15, 0.2(5.9); 16, 0.2(6.1); 17, 0.4(6.5); 18, 0.2(6.7); 19, 0.2(6.9). Approximately ×2; length 1o.5 mm; USNM 380684; Locality S1409.

region swollen; flanks steep. Fold poorly defined, occupied by 3 to 5 costae.

Interior: Pedicle valve with strong dental plates, erect with narrow umbonal chamber. Pedicle collar long, excavated, semitubular. Dorsal valve with moderately large septalium, long median septum.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement from imperfect specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380260a	14.7	12.2	12.0	12.8	72	6.5
380260b	12.7	10.5	10.7	10.2	78	5.5
380621a	13.5	10.7	9.7	11.4	72	4.6
380621b	13.5	10.8	10.6	11.0	72	4.0
380621c	12.8	10.6	10.0	10.6	71	4.0
380621d	13.7	11.7	11.6	11.0	72	4.0?
380621e	15.3	12.5	12.0	12.7	72	4.8
380621f	14.7	12.3	12.0	12.6	73	5.8

OCCURRENCE.—Lower Dhruma Formation (between *Dorsetensia* and *Ermoceras* Zones): S1202. (*Ermoceras* Zone): S1409, S1661.

TYPES.—Holotype: USNM 380260b. Paratypes: 380260a, 380621a–f, 380684.

DISCUSSION.—The narrow elongate form and fairly long beak are distinctive characters of this species that distinguish it from other species of *Schizoria*.

Schizoria intercalata, new species

PLATE 13: FIGURES 14–18

DIAGNOSIS.—Small nearly circular *Schizoria*.

DESCRIPTION.—Small, subcircular, subequivalve; rounded sides, anterior rounded. Apical angle variable. Lateral commissure straight; anterior commissure broadly uniplicate. Beak short, foramen small, hypothyridid; deltidial plates disjunct, with marginal rims. Costae rounded. Intercalations and bifurcations in two generations; about 19 costae.

Ventral valve unevenly convex in lateral view with greatest convexity in the umbonal region. Gently and broadly convex in anterior view. Sulcus poorly defined, consisting of five costae; tongue short.

Dorsal valve evenly, gently convex in side view, moderately domed in anterior profile. Fold poorly defined, slightly elevated at anterior half, with 6 costae.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380391	11.3	9.3	12.0	8.4	89	6.0
380602	12.8	11.4	12.4	10.0	98	6.0

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1409, S1677.

TYPES.—Holotype: USNM 380391. Paratype: USNM 380602.

DISCUSSION.—This is the smallest species of *Schizoria* and is distinguished from *S. intermedia*, new species, by its nearly circular outline and plump valves.

Schizoria intermedia, new species

PLATE 13: FIGURES 19–24

DIAGNOSIS.—Small, elongate oval, intermediate between *S. dividicostata*, new species, and *S. intercalata*, new species.

DESCRIPTION.—Small, elongate oval, dorsal valve deeper and more convex than ventral valve. Maximum width at about midvalve. Sides rounded, apical angle acute. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak short, incurved. Foramen small, deltidial plates disjunct. Costae numerous, subangular, numbering about 19. Intercalations few.

Ventral valve gently, evenly convex in lateral view; gently domed with slight median depression in anterior view. Umbonal region somewhat narrowly swollen. Sulcus shallow, originating at midvalve, occupied by 3 or 4 costae.

Dorsal valve fairly strongly convex in side view; narrowly domed in anterior profile. Whole valve swollen. Fold beginning at or somewhat posterior of midvalve, low, raised slightly above steep, rounded flanks in anterior third or half. Fold with 4 or 5 costae.

Interior: Ventral valve with long divergent dental plates. Dorsal valve with median septum reaching midvalve, septalium small.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380388a	13.8	12.2	11.6	10.6	78	4.5
380388b	14.7	12.4	12.0	10.0	78	5.0

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1677.

TYPES.—Holotype: USNM 380388a. Paratypes: USNM 380388b–e.

DISCUSSION.—This is a small elongate oval form which is distinguished from *S. dividicostata*, new species, by its smaller size and less expanded anterior. It differs from *S. intercalata* new species, in its larger size and elongate oval outline. *Schizoria elongata*, new species, is larger than *S. intermedia*, rounder in side view, with more closely crowded costae in sulcus, on fold and in flanks.

Schizoria rotundata, new species

PLATE 13: FIGURES 25–30

DIAGNOSIS.—Small, rotund finely costate *Schizoria*.

DESCRIPTION.—Small, rotund, slightly longer than wide, dorsal valve more convex than ventral valve. Anterior truncate; anterolateral margins rounded; apical angle acute. Lateral commissure straight, anterior commissure narrowly uniplicate. Beak small, erect; foramen narrow, hypothyridid. Deltidial plates disjunct. Surface with 24 fine, flatly rounded costae, separated by striae narrower than costae.

Ventral valve moderately convex in lateral view, nearly flat in anterior view. umbonal region swollen. Sulcus broad, shallow, originating at midvalve, occupied by 5 costae. Tongue long, rounded at extremity.

Dorsal valve strongly convex in anterior profile; strongly domed, with precipitious sides in anterior view. Umbonal and median regions swollen. Fold originating at about midvalve, low, visible in anterior third, occupied by 6 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380389: length 13.0; dorsal valve length 11.6, width 12.2, thickness 11.9, apical angle 75°, fold width 6.3.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone); S1661.

TYPE.—Holotype: USNM 380389.

DISCUSSION.—This species is similar to *S. costellata*, new species, in its fine costae. It differs from that species in its smaller size, more pronounced fold and sulcus with its long tongue.

Schizoria secta, new species

PLATE 14: FIGURES 28–46

DIAGNOSIS.—Large *Schizoria* with strongly convex valves.

DESCRIPTION.—Large for genus, subpentagonal, longer than wide, maximum width anterior to midvalve. Dorsal valve more convex and deeper than ventral valve. Beak narrow, incurved, pressed onto dorsal umbone. Foramen small, hypothyridid; deltidial plates concealed. Costae number 21 at anterior; bifurcation and intercalation in 2 generations.

Ventral valve moderately convex in lateral view, umbonal region most convex; anterior view flatly domed with round steep sides. Sulcus originating near midvalve, shallow, drawn anteriorly into long tongue occupied by 4 costae one or more of which may be bifurcated.

Dorsal valve moderately convex in side view; narrowly domed in anterior profile. Umbonal and median regions strongly swollen. Fold beginning at midvalve, moderately elevated anteriorly, composed of 4 or 5 costae one or more of which may be bifurcated.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380231a	16.8	14.3	13.8	14.0	72	7.9
380231b	13.7	12.0	11.9	10.2	79	6.0

OCCURRENCE.—Lower Dhruma Formation (Between *Dorsetensia* and *Ermoceras* zones): S1057.

TYPES.—Holotype: USNM 380231a. Paratypes: USNM 380231b,c.

DISCUSSION.—This species is about the same size as *S. dividicostata*, new species, differing in having a more swollen dorsal valve, a longer, narrower tongue, and a somewhat nasute anterior.

Schizoria species 1

PLATE 14: FIGURE 6

This is the largest specimen referable to *Schizoria*. It occurs with *S. elongata*, new species. It has some similarity to the latter but is the only specimen of its size among 49 of the smaller species. The dorsal valve is strongly convex in side view and roundly domed with steep sides in anterior view. The ventral valve, except for the posterior is mostly eroded away. The dorsal valve has 20 costae. The fold is indistinct and has 6 costae.

MEASUREMENTS (in mm).—USNM 380261: length 19.0, dorsal valve length 16.4, width 16.0, thickness 15.7? (estimated from imperfect specimen), apical angle 84°, fold width ? (measurement not possible from imperfect specimen).

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1409.

SPECIMEN EXAMINED.—USNM 380261.

Schizoria species 2

PLATE 13: FIGURES 31–36

This is a medium-size species for the genus. The lot consists of 3 specimens, all damaged, one crushed beyond usefulness,

a fairly large one with great thickness somewhat exaggerated due to deformation and a juvenile specimen which is nearly complete. The species suggests *S. secta*, new species in its plumpness and beak resting on dorsal umbo. It is, however, more finely costate and has a fairly deep, narrow sulcus with 3 costae. In this latter character it suggests forms of *S. elongata*, new species, but is larger and shorter.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate estimated measurements and measurements not possible from imperfect specimens.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380393a	11.7	10.5	10.8	11.8	77?	?
380393b	13.3	11.4?	12.5	15.0	78	?

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras*? Zone): S997.

SPECIMENS EXAMINED.—Figured and described specimens: USNM 380393a–c.

Somalirhynchia Weir, 1925

Somalirhynchia africana Weir

PLATE 12: FIGURES 37–41

Somalirhynchia africana Weir, 1925:79.—Muir-Wood, 1935:94.—Abbate et al., 1974:439, pl. 39: fig. 4.

Large, subtriangular, wider than long, strongly inequivalve, greatest width anterior to midvalve, sides narrowly rounded, apical angle obtuse. Anterior commissure strongly uniplicate. Beak erect; foramen small; deltidial plates disjunct. Costae about 26, rounded with narrow interspaces.

Ventral valve gently convex in side view, broadly concave with narrowly rounded flanks in anterior profile. Sulcus originating anterior of midvalve, deepening rapidly to produce very long tongue with 6 costae.

Dorsal valve subtriangular in anterior view, highly domed with protuberant median fold in anterior profile. Fold starting near midvalve, strongly elevated in anterior third. Fold with 7 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380381: length 28.0, dorsal valve length 26.4, width 33.7, thickness 32.6, apical angle 97°, fold width 16.9.

OCCURRENCE.—Hanifa Formation: S1048.

TYPE.—Hypotype: USNM 380381.

DISCUSSION.—Large size and extreme development of fold and sulcus distinguish this species from other somalirhynchiids described herein. A similar specimen was seen in a collection from the Oxfordian at Gebel Tyuriat, Sinai Peninsula, Egypt (USNM 402740).

Somalirhynchia arabica, new species

FIGURE 32; PLATE 14: FIGURES 1–5, PLATE 15: FIGURES 25–35

DIAGNOSIS.—Widely triangular *Somalirhynchia* with wide fold and sulcus, numerous crowded costae.

DESCRIPTION.—Large, thin-shelled, subtriangular, wider than long, maximum width anterior to midvalve. Dorsal valve more convex than ventral valve. Apical angle variable. Lateral commissure oblique. Beak short, low, suberect to erect; foramen large; deltidial plates disjunct or conjunct anteriorly thickened and elevated. Costae narrowly rounded to subangular, crowded separated by striae narrower than costae, about 30 costae.

Ventral valve gently, unevenly convex in side view; almost flat with broad gentle depression in anterior profile. Umbonal and median regions gently swollen. Sulcus broad, shallow, originating at about midvalve occupied by 6 to 10 costae; tongue long, broadly rounded.

Dorsal valve, evenly, moderately convex in side view; broadly domed with steep, rounded sides in anterior profile. Valve swollen. Fold starting at midvalve, low, prominent but not strongly elevated above flanks in anterior third. Fold with 7 to 12 costae.

Interior: Ventral valve with short, pedicle collar, hook-like teeth; dental plates subparallel, occupying less than 1/3 valve length. Muscle scars lightly impressed.

Dorsal valve interior with short, narrow septalium; median septum long, thin, reaching to about midvalve. Sockets narrow, corrugated. Outer hinge plate broad, shallow, concave; crura radulifer, moderately long, anteriorly expanded. Adductor scars not impressed on thin shell.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate estimated measurement and not possible to measure from imperfect specimens, respectively.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380206	26.5	23.0	30.0	21.0	98	16.4
380371a	30.8	27.0	32.0	22.0	98	18.7
380371b	27.0	23.8	29.8	17.5	106	18.0
380371c	27.0	23.3	29.3	18.2	99	14.6
380271d	26.6	23.5	27.8	18.0	102	13.7?
380371e	24.2	21.9	26.0	15.5	100	14.0
380371f	26.5	23.7	26.5	18.0	97	15.1
380371g	26.5	23.2	24.2	18.7	93	14.6
380371h	14.6	13.0	15.0	6.6	93	7
380571	22.5	20.0	25.0	18.0	109	12.2
380572	28.0	24.5	29.1	19.7	109	17.3
380573	25.0	22.0	30.3	17.0	108	15.0

OCCURRENCE.—Upper Dhruma Formation (Hisyan Member): S1445. Tuwaiq Mountain Formation: S1458. Hanifa Formation: S149, S1050, S1298, S1443, S1682. KK10-01, -22.5, -25, -25.5, -26, -26.5, -37.5.

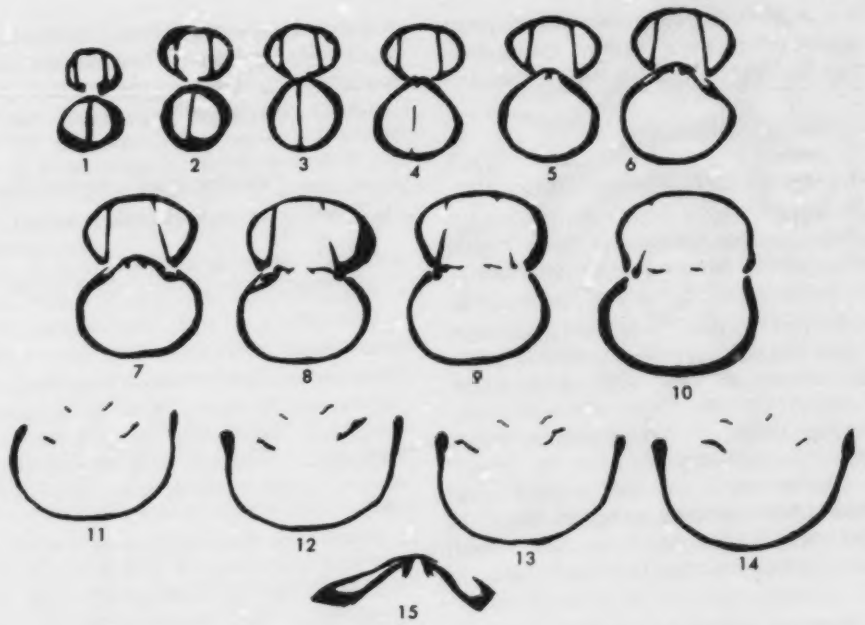

FIGURE 32.—*Somalirhynchia arabica*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.8(0.8); 2, 0.4(1.2); 3, 0.3(1.5); 4, 0.2(1.7); 5, 0.3(2.0); 6, 0.3(2.3); 7, 0.3(2.6); 8, 0.3(2.9); 9, 0.2(3.1); 10, 0.3(3.4); 11, 0.6(4.0); 12, 0.3(4.3); 13, 0.3(4.6); 14, 0.2(4.8). Approximately ×2. 15, Detail of section 6; ×3; length 22.0 mm; USNM 402739; Locality KK10-25.5.

TYPES.—Holotype: USNM 380206. Paratypes: USNM 380209, 380298, 380299, 380371a-h, 380514, 380571, 380572, 380573, 402739.

DISCUSSION.—This species differs from *S. africana* Weir in having smaller, rounder, and with closely crowded, finer costae. There are also more costae on fold and sulcus than in *S. africana*.

Somalirhynchia arabica differs from *S. somalica* (Dacque) in its larger size and more regular, subtriangular form with more costae in fold and on sulcus.

Young specimens of *S. arabica* are very narrowly biconvex and show no evidence of fold or sulcus. They do not have dorsal sulcation in the umbonal region. A fold and sulcus are developed at about 16 mm.

Of the species of *Somalirhynchia* figured by Muir-Wood (1935), *S. arabica* is most like *S. africana jordanica* in having numerous closely crowded costae. However, *S. arabica* has a stronger fold than the African species.

Somalirhynchia has a wide areal distribution having been identified in Tunisia (Dubar, 1967), Scotland and Russia (Childs, 1969), and Morocco and Spain (Ager and Walley, 1977).

Somalirhynchia deficiens, new species

PLATE 14: FIGURES 12–16

DIAGNOSIS.—*Somalirhynchia* with strongly swollen dorsal valve, with length and width nearly equal.

DESCRIPTION.—Large, roundly triangular, maximum width at midvalve; sides rounded, anterior broadly rounded; apical angle obtuse. Lateral commissure straight; anterior commissure widely uniplicate. Beak narrow, low; foramen large; deltidial plates disjunct thinning posteriorly. Costae narrowly subangular, separated by striae of about equal width to that of costae, costae numbering about 27.

Ventral valve gently convex in side view; anterior view nearly flat with broad median depression. Valve gently swollen. Sulcus starting posterior of midvalve, shallow, only slightly depressed below narrowly rounded flanks in anterior half. Sulcus with 7 costae.

Dorsal valve strongly convex in side view, forming broad dome with steep sides in anterior profile. Valve strongly swollen. Fold low, starting about midvalve, moderately elevated above flanks at anterior. Fold with 8 costae.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement from imperfect specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380372	28.0	24.3	28.7	19.6	92	15.07
380574	26.6	23.0	30.0	20.6	104	15.7
380622	29.3	25.0	29.3	24.0	96	16.0

OCCURRENCE.—Upper Dhruma Formation (Atash Member): S1730. (Upper Atash–Lower Hisyan members): S1462. Tuwaiq Mountain Formation: S154, S296, S459, S1199, S1458, S1715.

TYPES.—Holotype: USNM 380372. Paratypes: USNM 380574, 380622.

DISCUSSION.—This species is most like *S. arabica*, new species, from which it differs in having strongly swollen dorsal valve and stronger costae. It differs from *S. somalica* (Dacqué) in its larger size, wider shell and more numerous costae.

Somalirhynchia prearabica, new species

PLATE 13: FIGURES 46–50

DIAGNOSIS.—Narrowly triangular *Somalirhynchia* with narrow fold and sulcus, acute apical angle.

DESCRIPTION.—Large, narrowly triangular, maximum width anterior to midvalve; slightly longer than wide; apical angle 75°. Anterolateral extremities narrowly rounded. Anterior commissure somewhat narrowly uniplicate. Beak moderately long, narrow, suberect; foramen large, oval; deltidial plates disjunct, margin posteriorly rimmed. Costae rounded, numbering 26.

Ventral valve gently convex in side view, forming low dome with depressed median region in anterior profile. Sulcus originating about midvalve, broad, shallow, depressed slightly below narrow flanks in anterior half, with 5 costae. Tongue long, narrowly rounded.

Dorsal valve moderately convex in side view, forming a high, rounded dome in anterior view. Valve swollen medially. Fold low, starting slightly posterior to midvalve, slightly elevated above rounded flanks in anterior half. Fold with 6 costae.

MEASUREMENTS (in mm).—USNM 380375: length 26.0, dorsal valve length 21.8, width 24.7, thickness 19.0, apical angle 75°; fold width 15.0.

OCCURRENCE.—Tuwaiq Mountain Formation: S1675.

TYPES.—Holotype: USNM 380375.

DISCUSSION.—This species is most like *S. somalica* (Dacqué); it differs however, in its smaller apical angle, stronger flatter costae and narrow fold and sulcus. These features distinguish this species from *S. arabica*, and *S. deficiens*, both new species.

Somalirhynchia prearabica is somewhat smaller than *S. arabica* and has a narrower fold and sulcus and stronger costae. *Somalirhynchia deficiens*, new species, is plumper than *S. prearabica* and has less crowded costae and longer beak.

Somalirhynchia somalica (Dacqué)

PLATE 15: FIGURES 1–23; plate 17: FIGURES 13–17, 23–27

Rhynchonella somalica Dacqué, 1905:127.
Somalirhynchia somalica (Dacqué).—Muir-Wood, 1935:102.

DESCRIPTION.—Large, subtriangular, length and width nearly equal; dorsal valve more convex than ventral valve. Sides rounded, anterior margin broadly rounded; apical angle variable, usually obtuse. Lateral commissure oblique; anterior commissure strongly uniplicate. Beak, low, suberect; foramen fairly large; deltidial plates disjunct with incipient rims. Costae narrow, rounded, crowded, with narrow interspaces, numbering 24–30.

Ventral valve moderately convex in side view, gently domed with steep lateral slopes in anterior view. Umbonal and median regions swollen. Sulcus originating about midvalve, shallow, broad, flat, producing long wide, flattened tongue with 6 or 7 costae.

Dorsal valve strongly convex in side view; steeply domed with convex sides in anterior profile. Fold starting about midvalve, poorly defined, best seen at anterior, fold with 7 costae.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380277	22.7	18.0	22.4	20.7	96	10.4
380575	27.3	23.5	27.0	23.0	90	15.0

OCCURRENCE.—Dhruma Formation (*Tulites* Zone): S1488. (Hisyan Member): S1724. Tuwaiq Mountain Formation: S154, S293, S295, S296, S459, S800, S1199, S1458, S1702. Hanifa Formation: S625, S1298, KK10-33–34; -37.5.

TYPES.—Hypotypes: USNM 380273, 380277, 380286a, 380344, 380377, 380445, 380516, 380575, 380634a,b.

DISCUSSION.—This species is distinguished from other *Somalirhynchia* species in its flattened anterior when viewed from the anterior, its narrower fold, and more distinctly triangular form.

Sphenorhynchia Buckman, 1917

Sphenorhynchia? angulata, new species

PLATE 14: FIGURES 7–11

DIAGNOSIS.—Small, narrowly elongate *Sphenorhynchia?*

DESCRIPTION.—Medium, elongate triangular, anterior margin rounded, apical angle acute. Dorsal valve slightly deeper and more convex than ventral valve. Lateral commissure straight, anterior commissure broadly, arcuately uniplicate. Beak, long, narrowly rounded, erect. Foramen and deltidial plates not preserved. Costae angular, numbering about 22.

Ventral valve gently convex in lateral view, gently convex in anterior profile. Sulcus visible only at anterior commissure, with 7 costae. Tongue short.

Dorsal valve moderately convex in lateral view, narrowly domed with steep sides in anterior view. Fold low, visible in anterior view, with 8 costae.

Interior: Ventral valve with narrowly divergent dental plates extending about 1/4 valve surface length. Dorsal interior with septum reaching to midvalve.

MEASUREMENTS (in mm).—USNM 380270: length 20.3, dorsal valve length 17.6, width 15.4, thickness 13.7, apical angle 77°, fold width 10.0.

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): S1422.

TYPE.—Holotype: USNM 380270.

DISCUSSION.—This species is narrower and smaller than other *Sphenorhynchia* described herein. Its form is suggestive of *S. ferryi* (Deslongchamps) as figured by Almeras (1980, pl. 6: fig. 12a–c); it differs from the French form, however, in more numerous costae and more elongate beak.

Sphenorhynchia varicostata, new species

FIGURES 33, 34; PLATE 16: FIGURES 21–45

DIAGNOSIS.—*Sphenorhynchia* with strong costae.

DESCRIPTION.—Large, narrowly triangular, unequally biconvex, dorsal valve deeper and more strongly convex than ventral valve: maximum width anterior to midvalve. Anterolateral extremities rounded; posterolateral margins forming acute angle. Lateral commissure straight; anterior commissure strongly uniplicate. Beak short, suberect; foramen small; deltidial plates disjunct, narrow posteriorly, thickened anteriorly. Costae subangular to narrowly rounded, 18–30.

Ventral valve moderately convex in lateral profile, gently convex to nearly flat with shallow median depression in anterior view. Umbonal region narrowly swollen. Sulcus shallow, originating near midvalve, widening anteriorly, occupied by 4–6 costae; sulcus depressed below flanks in anterior third to half. Tongue short, blunt, often gently convex. Flanks narrow, steep, moderately rounded.

Dorsal valve strongly convex in lateral profile; strongly, roundly domed with steep sides in anterior view. Umbonal and

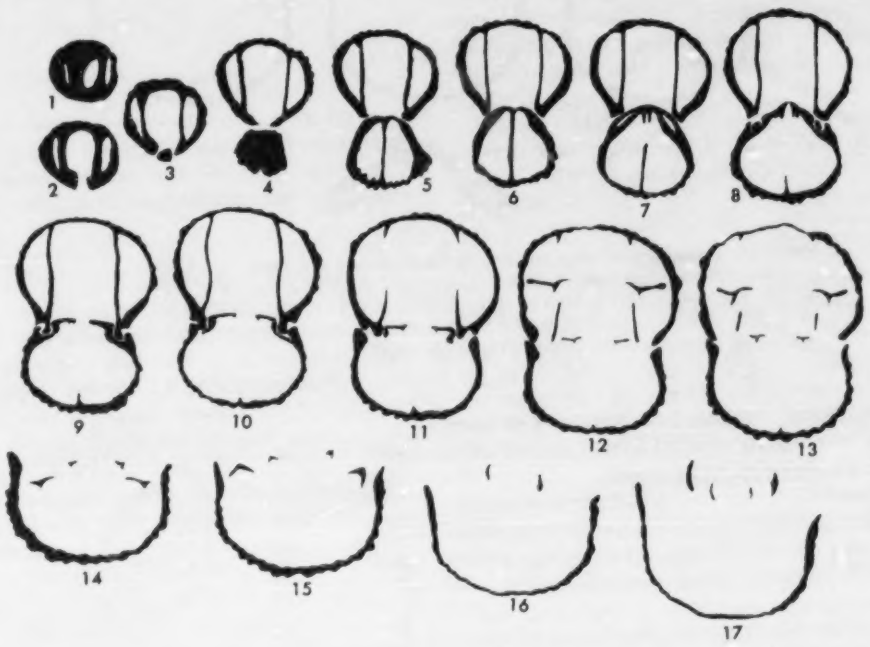

FIGURE 33.—*Sphenorhynchia varicostata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.9(0.9); 2, 0.5(1.4); 3, 0.4(1.8); 4, 0.5(2.3); 5, 0.3(2.6); 6, 0.4(3.0); 7, 0.3(3.3); 8, 0.2(3.5); 9, 0.3(3.8); 10, 0.2(4.0); 11, 0.4(4.4); 12, 0.3(4.7); 13, 0.2(4.9); 14, 0.3(5.2); 15, 0.3(5.5); 16, 0.6(6.1); 17. 0.2(6.3). Approximately ×2; length 23.4 mm; USNM 380687; Locality S1485.

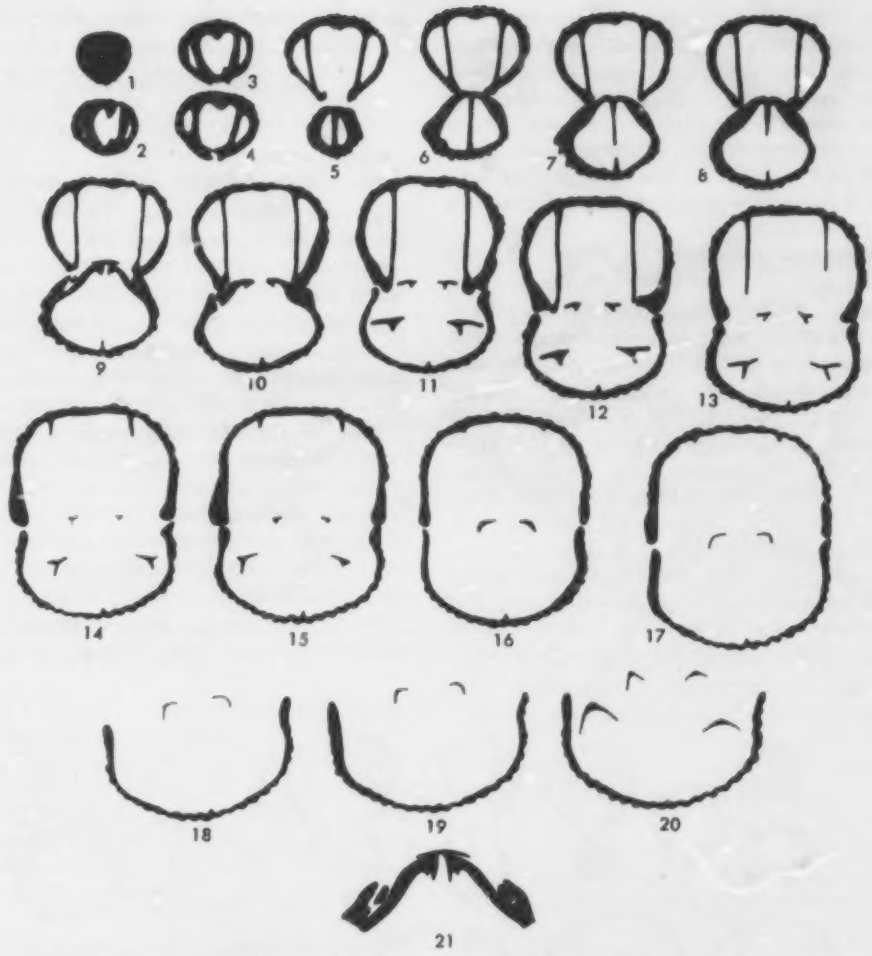

FIGURE 34.—*Sphenorhynchia varicostata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.5(0.5); 2, 0.3(0.8); 3, 0.4(1.2); 4, 0.4(1.6); 5, 0.5(2.1); 6, 0.5(2.6); 7, 0.1(2.7); 8, 0.3(3.0); 9, 0.3(3.3); 10, 0.3(3.6); 11, 0.5(4.1); 12, 0.2(4.3); 13, 0.3(4.6); 14, 0.3(4.9); 15, 0.2(5.1); 16, 0.2(5.3); 17, 0.2(5.5); 18, 0.2(5.7); 19, 0.2(5.9); 20, 0.2(6.1). Approximately ×2. 21, Detail of carinalia of section 9 ×4; length 24.4 mm; USNM 380688; Locality S1617.

median regions strongly swollen. Fold originating at about midvalve, low, only slightly elevated at anterior third often slightly protuberant, occupied by 5–9 costae.

Interior: Ventral valve with divergent dental plates reaching 1/3 valve length; occasional myophragm between dental plates. Dorsal valve interior with long, slender median septum reaching about to midvalve. Septalium small, narrow, crura radulifer.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380197	31.2	27.0	27.2	22.7	84	14.8
380221a	24.1	21.3	22.0	17.5	95	12.5
380594a	25.3	21.8	22.4	17.8	80	12.3
380594b	28.3	24.3	24.2	21.7	81	14.3
380594c	23.5	20.0	19.2	17.0	76	11.2
380594d	27.7	23.7	23.0	20.8	77	12.0
380595a	29.0	25.8	25.0	20.5	78	13.0
380595b	28.8	25.4	22.9	20.0	78	16.3
380596	23.6	21.0	21.0	16.8	88	10.8
380623a	26.5	23.3	24.3	21.0	80	13.7
380623b	25.0	21.9	21.0	18.5	77	11.3

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1485, S1506, S1617, S1695; (*Thambites* Zone): S1503; (*Tulites* Zone): S1488; (Zone not placed): S1652.

TYPES.—Holotype: USNM 380197. Paratypes: USNM 380194a, b, 380221a-c; 380228a,b, 380439, 380447, 380594a–e, 380595a–c, 380596, 380623a,b, 380687, 380688.

DISCUSSION.—The two sets of serial sections shown here (Figures 33, 34) have some differences in the crura. This is due possibly to a slight difference in size or more probably to a slight difference in the position of the crura in the specimens, resulting in the crura being cut at slightly different angles.

This is a variable species in which the costae vary in number from 18–30. There is variation in form, some of which may be due to flattening of the shell to produce shells wider than normal.

This species differs from *Sphenorhynchia plicatella* (J. de C. Sowerby, 1825) in its smaller size and stronger costation. The deltidial plates are disjunct unlike the species of *Sphenorhynchia* described by Almeras (1980). This species also suggests the stronger costate forms of *S. bugeysiaca* (Riche) from the Bathonian of Ain, France, figured by Almeras (1980, pl. 4: figs. 1–3). The French specimens, however, are larger and longer than those from Saudi Arabia. Almeras regarded the finer costate forms as specifically like the coarser ones. This sort of relationship applies for the Saudi Arabian specimens too, because the coarser and finer costate ones lived together.

Strongyloria, new genus

TYPE SPECIES.—*Strongyloria circularis*, new species.

DIAGNOSIS.—Round, subequally convex rhynchonellids with small foramen, arcuate anterior commissure, well-developed dental plates, moderate median septum and radulifer crura.

SPECIMENS STUDIED.—5.

GEOLOGICAL OCCURRENCE.—Bajocian to Bathonian.

ETYMOLOGY.—Greek *strongylos* (round).

DESCRIPTION.—Large, subelliptical to subcircular; valves of nearly equal convexity; greatest width at midvalve. Lateral commissure straight, anterior commissure arcuately gently uniplicate. Beak low, incurved; foramen small, hypothyridid. Deltidial plates disjunct. Costae low, rounded, numerous with intercalation and bifurcation on umbones.

Ventral valve with short pedicle collar; dental plates short.

Interior: Dorsal valve with small, short septalium, fairly long median septum; radulifer crura.

DISCUSSION.—This rhynchonellid is unlike any Bajocian form yet described. It is suggestive of some species of *Cymatorhynchia* Buckman (1917) but that genus is more triangular, less numerously costate, without bifurcation or intercalation of costae, with larger foramen and strongly uniplicate anterior commissure. It differs from *Rhactorhynchia* (Buckman, 1917), which is similar externally to *Cymatorhynchia*, by the same characters. No other Saudi Arabian genus is similar to this one although the young of *Conarosia*, new genus, are suggestive. They are usually costellate rather than costate and more triangular with stronger, narrower uniplication.

Strongyloria circularis, new species

FIGURE 35; PLATE 16: FIGURES 1–10

DIAGNOSIS.—*Strongyloria* with length and width nearly equal.

DESCRIPTION.—Large moderately biconvex, valves nearly equally convex, subcircular, with length and width nearly equal. Sides and anterior margins rounded. Apical angle obtuse. Lateral commissure straight; anterior commissure with gentle arcuate uniplication. Beak small, short, incurved; foramen small, hypothyridid. Deltidial plates anteriorly thickened, narrowed posteriorly, disjunct. Costae numbering about 33, flatly rounded, separated by narrow striae, crowded, bifurcated, and intercalated on the umbones.

Ventral valve gently convex in side view; broadly, gently domed in anterior profile. Umbonal and median regions gently swollen; anterior third somewhat flattened to form short broadly rounded tongue, with nine costae.

Dorsal valve gently convex in side view, slightly more convex than ventral valve; moderately domed in anterior view. Median region and anterior swollen to form ill-defined fold with 10 costae. Flanks convex, rounded, moderately steep.

Interior as for genus.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate estimated measurements of incomplete or damaged specimens.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380200a	19.7	18.0	19.8	15.5	113	13.0?
380200b	20.7	19.0	24.0	15.5	105	15.3?
380384a	26.4	24.0	26.4	18.4	98	20.0
380384b	23.0	21.6	23.6	15.5	117	?

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1167, 1170, KK7-3+1.

TYPES.—Holotype: USNM 380200a. Paratypes: USNM 380200b, 380384a,b, 400917.

DISCUSSION.—This species is much rounder, larger and more swollen than *S. subelliptica*, new species.

Serial sections show fairly short dental plates, a long fairly high median septum, and radulifer crura suggestive of those figured by Childs for *Septaliphoria* (1969, figs. 31–33).

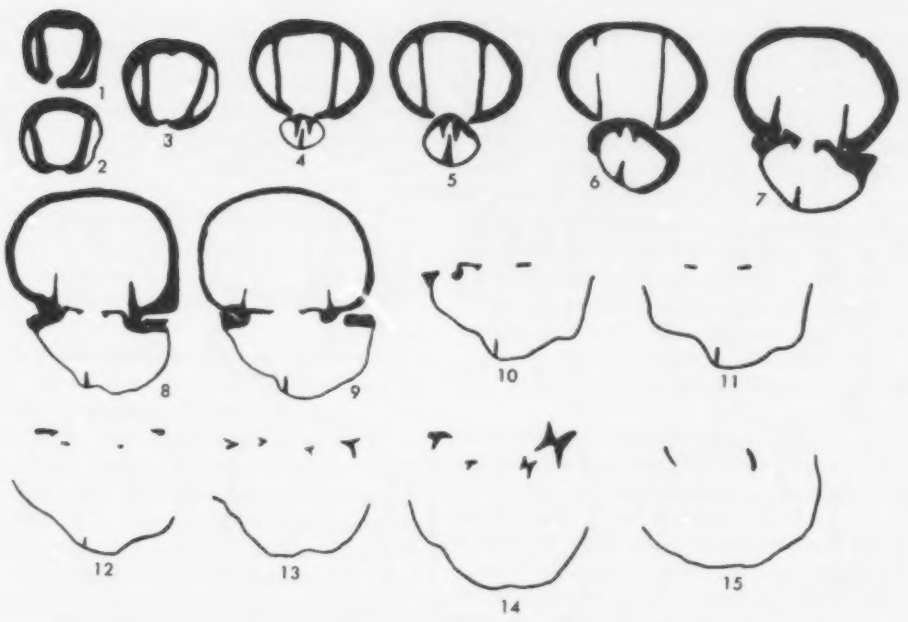

FIGURE 35.—*Strongyloria circularis*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.2(0.8); 3, 0.2(1.0); 4, 0.4(1.4); 5, 0.2(1.6); 6, 0.3(1.9); 7, 0.3(2.2); 8, 0.3(2.5); 9, 0.4(2.9); 10, 0.2(3.1); 11, 0.2(3.3); 12, 0.2(3.5), 13, 0.2(3.7); 14, 0.3(4.0); 15, 0.3(4.3). Crura disappear at 4.7 mm anterior to beak; approximately ×2; length 21.0 mm; USNM 400917; Locality KK7-3±1.

Strongyloria subelliptica, new species

PLATE 16: FIGURES 11–15

DIAGNOSIS.—*Strongyloria* slightly longer than wide.

DESCRIPTION.—Slightly longer than wide; valves subequally convex with dorsal valve slightly more convex than ventral valve. Sides and anterior rounded; maximum width at about midvalve; uniplication arcuate. Beak low with moderately large foramen. Deltidial plates disjunct, wide anteriorly, narrow posteriorly. Fold low, inconspicuous with about 7 costae. Sulcus shallow, defined in anterior third only. Costae numbering about 30.

Interior unknown.

MEASUREMENTS (in mm).—USNM 380218: length 20.0; dorsal valve length 19.0; width 18.7; thickness 13.7 (dorsal valve slightly indented); apical angle 100°; fold width 9.0.

TYPE.—Holotype: USNM 380218.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): KK8-33.5.

DISCUSSION.—Slightly less round and with narrower fold than *S. circularis*, new species.

Torquirhynchia Childs, 1969

Torquirhynchia? convexa, new species

PLATE 16: FIGURES 16–20

DIAGNOSIS.—Finely costate, subtriangular *Torquirhynchia?*

DESCRIPTION.—Large, subtriangular, length and width about equal. Dorsal valve deeper and more convex than ventral valve. Anterior broadly rounded, anterolateral extremities narrowly rounded; apical angle acute. Lateral commissure straight; anterior commissure uniplicate, offset by ventral twist of valves. Beak long, foramen large; deltidial plates disjunct, wide anteriorly, rimmed posteriorly. Costae narrowly angular, crowded, separated by striae about equal in width to costae, about 33.

Ventral valve gently convex in side view, broadly, gently convex in anterior view. Umbonal and median regions swollen; sulcus wide originating at midvalve, with 10 costae. Sides narrowly rounded, steep.

Dorsal valve strongly convex in side view, strongly domed with steeply sloping sides in anterior profile. Fold low, wide, with 11 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380275: length 26.0, dorsal valve length 22.3, width 27.3, thickness 22.0, apical angle 78°, fold width 14.6.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPE.—Holotype: USNM 380275.

DISCUSSION.—This species has the left side depressed. It differs from *T. inconstans* (J. Sowerby, 1821) in its smaller size, finer costation, more triangular form, and more elongate beak.

Torquirhynchia? parva, new species

PLATE 12: FIGURES 42–46

DIAGNOSIS.—Small *Torquirhynchia*.

DESCRIPTION.—Medium, subpentagonal, wider than long dorsal valve deeper and more convex than ventral valve. Sides narrowly rounded, anterior margin broadly rounded. Apical angle obtuse. Lateral commissure oblique; anterior commissure uniplicate with right side depressed. Beak low, foramen small, hypothyridid. Deltidial plates narrow, disjunct. Costae subangular, crowded with striae narrower than costae, about 30 costae.

Ventral valve, evenly, gently convex in side view; gently convex in anterior view. Whole valve swollen. Sulcus originating anterior to midvalve, shallow, slightly depressed below flanks, occupied by 7 costae. Tongue long.

Dorsal valve strongly convex in side view, strongly domed in anterior view. Valve swollen. Fold beginnng anterior to midvalve, low, slightly elevated above rounded, swollen flanks. Fold with 8 costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380281: length 18.3, dorsal valve length 15.6, width 19.8, thickness 15.2, apical angle 97°, fold width 11.0.

OCCURRENCE.—Hanifa Formation: KK10-37.5.

TYPE.—Holotype: USNM 380281.

DISCUSSION.—This species is smaller than any described species of the genus, which normally tends toward large shells. A similar species with somewhat finer ornament occurs in the Callovian at Gebel Tyuriat, in the Sinai Peninsula, Egypt (USNM 400918).

Rhynchonellacean Genus and Species Undetermined

PLATE 17: FIGURES 18–22

A fine specimen of rhynchonellid suggests *Nastosia* in external appearance but has widely divergent dental plates and occurs in the Oxfordian rather than in the Bajocian part of the Jurassic column. The specimen is elongate oval, with maximum thickness anterior of midvalve. The lateral commissure is straight and the anterior commissure strongly uniplicate. The beak is low, the foramen small, hypothyridid with thick disjunct deltidial plates. There are 16 strong rounded costae separated by narrower striae.

The ventral valve is gently convex in side view, medially and flatly concave in anterior view. The sulcus is narrow, fairly deep and occupied by 3 broad costae. The dorsal valve is fairly strongly convex and deep in side view, strongly and narrowly domed in anterior view. The fold is narrow, not well defined and is occupied by 4 costae. Ventral tongue short distally serrate.

Interior not seen except for divergent dental plates.

MEASUREMENTS (in mm).—USNM 380635: length 23.3, dorsal valve length 21.4, width 22.3, thickness 20.3, apical angle 76°, fold width 10.6.

OCCURRENCE.—Tuwaiq Mountain Formation: S1675.

SPECIMEN EXAMINED.—USNM 380635.

Superfamily SPIRIFERINACEA Davidson, 1884

Family SPIRIFERINIDAE Davidson, 1884

Members of this superfamily are confined to the Marrat Formation. *Calyptoria* is a new taxon characterized by its smooth, nonpustulose or nonspinose shell. The other taxa *Liospiriferina* and *Spiriferina* have their shells covered by pustules or short fine spines. Although the name *Liospiriferina* is inapt for a genus covered by small spines, the name may have referred to the lack of costation in some species; even there, however, costation is incipient or fairly strong in a number of species of *Liospiriferina*. Specimens of *Liospiriferina* and *Calyptoria* are common in the Marrat Formation; *Spiriferina* is rare.

Calyptoria, new genus

TYPE SPECIES.—*Calyptoria extensa*, new species.

DIAGNOSIS.—Spiriferacean with smooth shell surface, obscurely costate flanks.

DESCRIPTION.—Small to medium, spiriferoid, with smooth fold and sulcus, obscurely costate flanks. Surface smooth. Finely endopunctate. Ventral valve with dental plates shorter than median septum. Dorsal valve with wide sockets, short septal plates.

SPECIMENS STUDIED.—Many.

GEOLOGICAL OCCURRENCE.—Liassic (Toarcian).

ETYMOLOGY.—Greek *kalyptos* (cover), in allusion to the obscured costation.

DISCUSSION.—Two species of unlike appearance are included in this genus, one with elongated ventral valve, the other (*C. carinata*) with less elongate valve, both with nonspinose surface. Both show obscure lateral costation as well as having valve surface without spines or granules. The interarea of both species is curved and divided by an open delthyrium with narrow marginal plates. No trace of a complete cover was seen.

The dental plates of both species are shorter than the median septum which extends to midvalve or beyond and rises to a sharp point.

The genus differs from *Liospiriferina* in its completely smooth shell surface. The name *Liospiriferina* implies a smooth shell surface but its species have the shell surface pustulose or spiny. Moreover, some of the species are obscurely costate as well.

Callospiriferina Rouselle (1977) is strongly costate and has its posterior much thickened by punctate shell tissue, which gives the appearance of a 'spondylium' according to Rouselle (1977:157). The strong costation and unusual apical structure separate this genus from *Calyptoria*.

Dispiriferina Siblik (1965) is a strongly plicated genus without microornament. The plications of this genus and the strong plication of *Spriferina* (*S. walcotti* J. de C. Sowerby, 1823, type species) serve to separate these two genera from *Calyptoria*. *Spiriferina* is also spiniferous, or granulose.

Calyptoria carinata, new species

PLATE 31: FIGURES 1–3, plate 37: FIGURES 1–21

DIAGNOSIS.—*Calyptoria* with short palintrope and carinate fold.

DESCRIPTION.—Small to medium, subpentagonal, slighty wider than long; hinge narrower than midwidth. Sides rounded, anterior truncate. Beak moderately long, curved, apsacline. Surface smooth; costation obscure.

Ventral valve moderately convex in side view, broadly convex with angular, deep depression in anterior view. Sulcus originating at beak, angular, deep, forming long angular tongue (about 40°). Sides sloping steeply; flanks with 2 or 3 costae developed at anterior.

Dorsal valve evenly, moderately convex in side view, broadly convex with elevated sharp median fold in anterior profile. Fold originating at beak, angular to very narrowly rounded forming V at anterior. Flanks gently convex with three or more peripheral costae or none.

MEASUREMENTS.—All measurements are in millimeters.

USNM	*Length*	*Dorsal valve length*	*Midwidth*	*Hinge width*	*Thickness*
380324a	17.5	13.5	19.0	12.2	17.6
380324b	17.6	12.5	16.8	11.4	19.1
380324c	17.2	13.2	18.4	13.8	15.3
380324d	15.5	12.1	15.5	11.0	15.2
380324e	17.0	12.5	19.0	13.0	17.2
380326a	16.5	11.7	18.2	12.8	16.0
380326b	18.0	12.8	18.7	13.2	16.5
380330a	20.0	14.8	21.0	13.8	21.0
380330b	16.2	13.0	16.8	12.0	13.7
380330c	14.6	11.2	15.8	10.0	12.0
380330d	16.7	12.6	18.3	12.7	14.2

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S989, S1031, S1034; KK6-14.

TYPES.—Holotype: USNM 380324a. Paratypes: USNM 380324b–l, 380326a,b, 380330a–d.

DISCUSSION.—The ribbing of this species is often obscure, even in well-preserved specimens and is best seen on exfoliated examples. The smooth shell distinguishes this species from small specimens of *Liospiriferina obesa*, new species. Larger size and carinate fold are distinctions from *C. extensa*, new species.

Calyptoria extensa, new species

PLATE 19: FIGURES 1–13

DIAGNOSIS.—Small *Calyptoria* with extended ventral valve.

DESCRIPTION.—Small, outline subpentameroid, unequally convex, sides rounded. Ventral valve elongated with curved apsacline palintrope. Surface smooth, occasional obscure costae seen best on exfoliated specimens.

Ventral valve moderately convex in side view, narrowly domed with slight median depression in anterior view. Sulcus forming anterior of umbonal region, shallow, forming short rounded tongue at anterior. Flanks narrowly rounded. Costation seen chiefly on margins consisting of 2 or 3 serrations on shell edge.

Dorsal valve moderately convex in side view; strongly domed with slight median elevation in anterior profile. Fold low, originating on umbonal region, narrow forming deep, narrow U at front. Sides rounded, steep.

Interior: Ventral valve with median septum extending beyond midvalve. Dental plates short. Dorsal valve interior with low median septum extending to midvalve.

MEASUREMENTS.—All measurements are in millimeters.

USNM	*Length*	*Dorsal valve length*	*Midwidth*	*Hinge width*	*Thickness*
380322a	13.5	10.8	13.3	8.0	13.4
380322b	17.7	14.4	16.0	9.0	15.6
380323a	16.5	13.4	14.6	8.4	15.8
380323b	15.4	12.0	13.0	9.0	14.2
380323c	15.0	12.3	12.3	8.0	14.0
380323d	13.7	12.0	12.3	8.4	13.3
380323e	12.3	11.2	12.0	7.9	12.3

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S1030, S1034.

TYPES.—Holotype: 380323a. Paratypes: USNM 380322a,b, 380323b–g.

DISCUSSION.—This species resembles *Spiriferina tumida rupestis* Eudes Deslongchamps (as figured by Corroy, 1927, pl. 4, figs. 21–24) in having an elongated ventral palintrope. It is smaller than that subspecies, with more incurved interarea, narrower beak and more swollen dorsal valve.

Spiriferina adscendens E. and J.A. Eudes-Deslongchamps (1858) has the appearance of *Calyptoria extensa* with its elongated ventral valve. The French species is larger with less

incurved beak, deeper sulcus, and with strongly punctate surface. The latter is unlike the surface of *C. extensa* which is completely smooth. Fine endopunctae can be seen, however, where the shell of *C. extensa* is exfoliated.

Calyptoria extensa differs from its associate *C. carinata*, new species in its smaller size, more elongated ventral valve, and the rounder fold.

Liospiriferina Rouselle, 1977

Liospiriferina obesa, new species

PLATE 19: FIGURES 36–52

DIAGNOSIS.—Medium for genus, with strongly incurved beak, deep sulcus, narrow fold.

DESCRIPTION.—Fairly large, variable, subpentagonal, length and width nearly equal. Sides rounded, anterior truncated. Beak long, strongly incurved over apsacline interarea. Surface covered by minute pustules or short spines. Costae obscure; variable in number.

Ventral valve moderately to strongly convex in side view; rounded deeply concave medially in anterior profile. Flanks narrowly rounded. Sulcus starting at beak, narrow, forming rounded tongue. Sulcus deep and narrow in adult.

Dorsal valve moderately evenly convex in side view, roundly domed in anterior view, with steep rounded sides. Fold narrow, rounded, low, forming deep U at anterior.

MEASUREMENTS.—All measurements are in millimeters.

USNM	Length	Dorsal valve length	Midwidth	Hinge width	Thickness
380325	28.6	19.6	28.4	14.6	27.0
380327a	22.3	17.0	23.7	12.4	17.0
380329a	19.7	14.7	22.6	11.6	19.2
380521a	23.0	17.8	23.6	14.6	21.5
380608	23.9	19.6	29.6	21.0	24.1
402743	19.0	15.3	21.4	12.2	15.4

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S989, S990, S1034, S1175; (Nejdia Zone): S1628.

TYPES.—Holotype: USNM 380325. Paratypes: USNM 380327a-c, 380329a-c, 380347a–c, 380357, 380521a,b, 380608, 402743.

DISCUSSION.—This species conforms in most respects to *Liospiriferina* which has a shell covered by pustules or short spines as does *L. obesa*. One specimen of *L. obesa* from locality S989 has remnants of a deltidial cover similar to that seen in a specimen of *L. rostrata* Schlotheim (1822) from France (USNM 380469; Plate 19: figure 14). *Liospiriferina obesa* is suggestive of *L. rostrata*, which is a much larger species with proportionally wider shell, broader and lower fold and less incurved beaks. It is illustrated in this paper to show the deltidial structures and the fine hair-like spines covering the entire surface. *Spiriferina sicula corfuotica* Renz (1932) is suggestive of *L. obesa* differing in its narrower fold and sulcus and more elongated beak.

Liospiriferina obesa is suggestive of *Spiriferina rostrata madagascariensis* Thevinin (1908) but differs in having a more elongated beak and much narrower fold and deeper sulclus.

Liospiriferina vulgata, new species

PLATE 19: FIGURES 30–35

DIAGNOSIS.—*Liospiriferina* with low fold and suberect beak.

DESCRIPTION.—Medium size, width greater than length; sides broadly rounded, maximum width at midvalve. Beak short, interarea fairly broad, nearly flat, apsacline. Surface covered by mat of minute spines; obscurely, flatly costate.

Ventral valve gently convex in side view; broadly, moderately domed with median depression in anterior profile. Sulcus originating at beak, moderately wide at anterior, shallow. Tongue short, rounded. Flanks steep, slightly convex.

Dorsal valve evenly, gently convex in side view; moderately domed with slight median elevation in anterior profile. Fold starting at beak, low, narrowly rounded, bounding broad U anteriorly. Flanks gently inflated, steeply sloping.

MEASUREMENTS (in mm).—USNM 380328: length 23.0, dorsal valve length 20.0, width 26.5, hinge width 18.0, thickness 18.2.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S1034.

TYPE.—Holotype: USNM 380328.

DISCUSSION.—This species differs markedly from *Liospiriferina obesa*, new species, with which it occurs. It is wider hinged with less inflated valves and with shallower sulcus and lower, more rounded foid. This species is smaller, less wide, and with stronger fold than *L. rostrata* (Schlotheim, 1822).

Spiriferina d'Orbigny, 1847

Spiriferina species 1

PLATE 19: FIGURES 25–29

DESCRIPTION.—Medium size, wider than long, maximum width at midvalve; hinge about 0.8 valve width. Sides narrowly rounded; anterior broadly, gently rounded. Beak, apsacline, incurved; interarea curved, broad. Delthyrium open, with remnant of lateral plates on its sides. Plicate, plicae 5 or 6 on a side, low rounded, separated by spaces in width about equal to width of plicae. Entire surface covered by minute granules.

Ventral valve moderately convex in side view, broadly convex with median region marked by V-shaped depression in anterior view. Sulcus starting at beak, widening and deepening anteriorly, V-shaped in section. Tongue long, sharply pointed. flanks flatly convex, with 6 plicae.

Dorsal valve fairly strongly convex in side view, broadly domed with sharp median elevation. Fold subangular, starting

at beak, strongly elevated at anterior.

MEASUREMENTS (in mm).—USNM 380350: length 16.2, dorsal valve length 14.7, width 24.0, hinge width 18.7, thickness 16.4.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S1030.

SPECIMEN EXAMINED.— USNM 380350.

DISCUSSION.—The single specimen is suggestive of *S. munsteri* Davidson (1851–1852) as it is about the same size. it is, however, wider, with more elevated fold and longer ventral tongue.

Spiriferina species 2

PLATE 19: FIGURES 15–19

A single small specimen is slightly wider than long, with 3 plications on a side. The fold is carinate; the beak low, interarea apsacline. Surface granulose. This species differs from the foregoing in its lesser width and lesser number of costae.

MEASUREMENTS (in mm).—USNM 380624: length 14.8, dorsal valve length 12.4, width 18.5, hinge width 12.5, thickness 13.0.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S1030.

SPECIMEN EXAMINED.—USNM 380624.

Spiriferina species 3

PLATE 19: FIGURES 20–24

A probable third species is narrower than *Spiriferina* species 2 and has fewer plications. It is represented by a single specimen which shows its spiriferinoid affinites by its plication and granulose shell surface.

MEASUREMENTS (in mm).—USNM 380348: length 12.3, dorsal valve length 12.5; width 15.2, hinge width 10.6, thickness 12.7.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S1175.

SPECIMEN EXAMINED.—USNM 380348.

Superfamily TEREBRATULACEA Gray, 1840

The Marrat Formation has no terebratulids. The lower part of the Dhruma Formation has few identified terebratulaceans. Although these parts of the Saudi Arabia Jurassic have produced terebratulids, many are crushed and others so sparsely represented as to be of no use in description of the fauna.

Terebratulids increase in numbers relative to the rhynchonellaceans in the upper part of the Dhruma and appear in abundance and variety in the Tuwaiq Mountain Formation where they outnumber the rhynchonellaceans. They are common but not of much variety in the Hanifa Formation.

Among the Saudi Arabian terebratulids, folding of the commissure is nearly universal; the uniplicate condition is rare (*Glyphisaria* and *Pleuraloma*, new genus). The commonest folding is sulciplication: development of a sulcus in the dorsal fold and a corresponding costa in the sulcus of the ventral valve. Of considerable interest in the Tuwaiq Mountain Formation is the development of peripheral costae as shown by three new genera, *Pleuraloma*, *Dissoria*, *Arapsopleurum*, and two new species, *Striithyris costata*, and *Arabicella? costata*. In the Lias of Morocco both terrebratulids and zeilleriids became peripherally folded (Dubar, 1942). The development of costation suggests a possible change in the salinity of the Jurassic sea at the time.

Of the 28 genera of terebratulaceans 11 are new. The Buckman genera, somewhat tentatively identified, are *Avonothyris*, *Kutchithyris*, *Loboidothyris*, *Plectothyris*, *Sphaeroidothyris*, and *Stiphrothyris*, all Buckman 1917. All but one species of *Sphaeroidothyris* are identified on external characters as are *Dorsoplicathyris* Almeras (1971), *Pseudowattonithyris* Almeras (1971), and *Orthotoma* Quenstedt (1869). *Somalithyris* Muir-Wood, 1935, reveals its loop for the first time and *Bihenithyris* Muir-Wood, 1935, is represented by a variety of species, some exhibiting the loop.

Ectyphoria, new genus, is unusual for its resemblance to *Rugitela*, a zeilleriid. *Apatecosia*, *Dolichobrochus*, *Glyphisaria*, and *Gyrosina*, all of Cooper, 1983, are identified on the basis of their loops and folding. *Striithyris* is easily recognized by its exterior costellation; it is quite unlike the large Somali species. *Arabatia*, *Arabicella*, and *Arapsothyris*, all new genera, are large forms of the Upper Dhruma and Tuwaiq Mountain formations. *Dissoria* and *Pleuraloma*, new genera, are peripherally costate forms; *Pionopleurum*, new genus, is a plump form resembling *Sphaeroidothyris*. *Stenorina*, new genus, has a unique elongate form with subparallel sides. *Toxonelasma*, new genus, has dorsally convex hinge plates, and *Tanyothyris*, new genus, exhibits its loop in an elongated shell.

No terebratulaceans were found in the collection from the Marrat Formation although they are reported in the field data.

SUPRA-GENERIC HIERARCHY OF SAUDI ARABIAN TEREBRATULACEA

Family ORTHOTOMIDAE Muir-Wood, 1936
  Orthotoma Quenstedt, 1869
Family TEREBRATULIDAE Gray, 1840
  Subfamily CERERITHYRIDINAE Cooper, 1983
    Plectothyris Buckman, 1917; *Toxonelasma*, new genus
  Subfamily LISSAJOUSITHYRIDINAE Cooper, 1983
    Apatecosia Cooper, 1983; *Dorsoplicathyris* Almeras, 1971; *Stenorina*, new genus
  Subfamily LOBOIDOTHYRIDINAE Makridin, 1964
    Arabatia, new genus; *Arabicella*, new genus; *Arapsothyris*, new genus; *Avonothyris* Buckman, 1917; *Bihenithyris* Muir-wood, 1935; *Dolichobrochus* Cooper, 1983; *Ectyphoria*, new genus; *Habrobrochus*, Cooper, 1983; *Loboidothyris* Buckman, 1917; *Pionopleurum*, new genus;

Sphaeroidothyris Buckman, 1917; *Stiphrothyris* Buckman, 1917; *Striithyris* Muir-Wood, 1935; *Tanyothyris*, new genus

Subfamily LOPHROTHYRIDINAE Cooper, 1983

Pseudowattonithyris Almeras, 1971

Subfamily POSTEPITHYRIDINAE Tschorszhevsky, 1974

Arapsopleurum, new genus; *Glyphisaria* Cooper, 1983; *Gyrosina* Cooper, 1983; *Pleuraloma*, new genus; *Somalithyris* Muir-Wood, 1935

Family Uncertain

Dissoria, new genus; *Kutchithyris* Buckman, 1917

Family ORTHOTOMIDAE Muir-Wood, 1936

Orthotoma Quenstedt, 1869

Orthotoma? species

PLATE 25: FIGURES 8–11

DESCRIPTION.—Small, thin-shelled, circular, compressed. Ventral valve gently convex, dorsal valve nearly flat. Apical angle 111°. Commissures straight. Beak small, low, beak ridges angular, defining wide concave interarea. Foramen large, submesothyridid. Deltidial plates disjunct. Smooth.

MEASUREMENTS (in mm).—USNM 380265: length 11.0, dorsal valve length 9.7, width 11.6, thickness 5.5.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK7-39.

SPECIMEN EXAMINED.—USNM 380265.

DISCUSSION.—A single specimen was found by the Kauffman-Kier party. It is an inner filling with traces of very thin shell on the dorsal side. The filling unfortunately has preserved only some of the inner details. Elongate diductor muscle scars are visible in the umbonal region of the ventral valve; the dorsal musculature is not discernible. No septum.

Family TEREBRATULIDAE Gray, 1840

Apatecosia Cooper, 1983

Apatecosia inornata, new species

PLATE 20: FIGURES 1–5

DIAGNOSIS.—*Apatecosia* with narrow fold, fairly wide loop.

DESCRIPTION.—Fairly large, subpentagonal, ventral valve deeper than dorsal valve; maximum width slightly anterior of midvalve. Anterior narrowly rounded, sides broadly rounded; apical angle acute. Lateral commissure anteriorly convex toward ventral valve. Anterior commissure narrowly sulciplicate. Beak low, narrow, somewhat labiate, partially concealing symphytium. Foramen large, permesothyridid. Smooth.

Ventral valve gently convex in side view, broadly, moderately domed with steeply sloping sides in anterior view. Median and umbonal regions swollen. Sulcus occupying anterior third, shallow, with low rounded median fold extending one-third valve length toward posterior.

Dorsal valve flatly convex in side view, broadly domed with steep sides in anterior profile, slightly more domed than ventral valve. Fold composed of 2 short costae at anterior quarter, separated by short deep sulcus.

Interior: Ventral valve with short rim-like pedicle collar. Dorsal valve interior with wide semielliptical shelf-like cardinal process; Loop occupying 2/5 valve length, almost 2/5 valve width. Socket ridges thin; outer hinge plates short, narrow, concave, not tapered, attached dorsally. Crural processes strongly posterior of midloop, widely acute. Lateral lamellae fairly long, bowed laterally. Transverse band strongly arched posteroventrally, crest narrow, thin, protuberant. Terminal points fairly long.

LOOP STATISTICS.—USNM 380410: angle = 41°; W1/L1 = 0.78; L1/LD = 0.37; W1/WD = 0.35; a/L1 = 0.39, b/L1 = 0.61; c/L1 = 0.24; d/L1 = 0.15; e/L1 = 0.22; f/L1 = 0.39; g/WD = 0.31; g/W1 = 0.88; h/f = 0.13; h/L1 = 0.05; WD/LD = 0.82.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380297	29.0	23.5	22.4	?	69
380410	27.0	22.4	21.3	15.0	69

OCCURRENCE.—Tuwaiq Mountain Formation: S459.

TYPES.—Holotype: USNM 380410. Paratype: USNM 380297.

DISCUSSION.—This species differs from *A. varians*, new species in details of the loop, which is somewhat wider and in its general appearance and has a wider apical angle.

Apatecosia varians, new species

PLATE 20: FIGURES 6–10

DESCRIPTION.—Fairly large, narrowly elongate oval; maximum width anterior of midvalve; ventral valve deeper than dorsal valve. Anterior and sides rounded; apical angle acute (possibly somewhat laterally compressed). Anterior commissure narrowly sulciplicate. Beak short, narrowly rounded, labiate, concealing symphytium. Foramen large, mesothyridid. Smooth.

Ventral valve fairly strongly convex in side view, forming low steep-sided dome in anterior profile. Narrowly swollen in umbonal region, swelling extending to midvalve. Sulcus wide, shallow, starting at midvalve, occupied by strong, low, rounded costa extending beyond midvalve.

Dorsal valve flatly convex in side view, flatly domed with steep sides in anterior profile. Fold formed by two narrowly rounded costae originating at about midvalve; costae separated by narrow deep sulcus.

Interior: Ventral valve not seen. Dorsal valve interior with small semielliptical cardinal process. Socket ridges thin; hinge plates narrow, attached dorsally. Loop about 2/5 valve length, 1/4 valve width. Crural processes posterior of midloop, moderately long, sharply pointed. Lateral lamellae bowed slightly laterally. Transverse band strongly arched, thick laterally, arch narrow, thin. Terminal points moderate.

LOOP STATISTICS.—USNM 380480b: angle = 33°; W1/L1 = 0.55; L1/LD = 0.41?; W1/WD = 0.28; a/L1 = 0.45; b/L1 = 0.55; c/L1 = 0.30; d/L1 = 0.15; e/L1 = 0.20; f/L1 = 0.35; g/WD = 0.36; g/W1 = 1.27; h/f = 0.11; h/L1 = 0.04; WD/LD = 0.80? (estimated from imperfect specimen).

MEASUREMENTS (in mm).—USNM 380480a: length 28.4, dorsal valve length 24.7; width 21.0, thickness 15.6?, apical angle 51°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380480a. Paratype: USNM 380480b.

DISCUSSION.—The measured specimen has been distorted by lateral pressure on one side, making some of the measurements uncertain. The species differs from *A. inornata*, new species, in its somewhat more slender form with maximum width anterior and much smaller apical angle. The loop is narrower than that of *A. inornata*, but the crural processes are located posterior of midloop.

Arabatia, new genus

TYPE SPECIES.—*Arabatia concava*, new species.

DIAGNOSIS.—Large, triangular, unequally convex, ventral valve fairly strongly convex, dorsal valve gently convex posteriorly, concave anteriorly. Apical angle acute. Sulciplicate. Beak broadly rounded. Foramen medium, mesothyridid. Surface with incremental lines of growth only.

Loop fairly wide, about 2/5 valve length, 1/3 valve width. Crural processes near midloop.

SPECIMENS STUDIED.—23.

GEOLOGIC OCCURRENCE.—Callovian.

ETYMOLOGY.—Latin *arabs* (Arab).

DISCUSSION.—This genus somewhat resembles *Bihenithyris* Muir-Wood (1935). It is, however, differently shaped, being triangular rather than pentagonal. The adductor scars of *Bihenithyris* are narrow and flare widely unlike those of *Arabatia*, which are narrow, straight, and diverge at an angle of about 20°. The loop is differently proportioned than that of *Bihenithyris*.

Arabatia concava, new species

PLATE 20: FIGURES 20–26

DIAGNOSIS.—Large dorsal valve anteriorly concave, with narrow, straight, narrowly divergent adductor scars and loop length equal to 2/5 valve length.

DESCRIPTION.—Large, triangular, maximum width at anterior. Sides rounded at anterior forming acute angle. Anterior commissure widely sulciplicate. Beak, rounded, low, erect. Foramen medium, mesothyridid. Symphytium hidden. Surface with concentric growth lines.

Ventral valve fairly strongly convex in lateral view, broadly convex with apex of dome slightly angulated. Umbonal and posterior half swollen. Sulcus wide, shallow occupied by broad plication extending to about midvalve. Tongue short, bilobed.

Dorsal valve with posterior half flatly convex, anterior half gently concave. Anterior profile moderately domed with long sloping sides. Posteromedian region moderately swollen. Fold occupying 2/3 valve width, formed of 2 bounding plications with sulcus between extending nearly to midvalve.

Interior: Ventral valve not seen. Dorsal valve interior with elongate straight narrow adductor scars forming angle of about 20°. Loop length about 2/5 valve length, about 1/3 valve length. Crural processes located slightly anterior to midloop, thick, sharply pointed. Outer hinge plates short, dorsally attached.

LOOP STATISTICS.—USNM 380462b (imperfect loop): angle = 39°; W1/L1 = 0.74; L1/LD = 0.45; W1/WD = 0.33; a/L1 = 53; b/L1 = 0.47; c/L1 = 0.32; d/L1 = 0.21; e + f/L1 = 0.47; g/WD = 0.34; g/W1 = 1.00; h/F = ?; h/L1 = ?; WD/LD = 0.98.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380462a	37.5	32.0	34.8	19.7	71
380462c	27.5	23.7	27.4	14.2	71
380462d	22.8	19.7	23.3	12.8	82
380462e	19.4	16.0	19.7	10.0	73
380462f	15.5	13.3	14.4	7.8	85
380462h	27.0	23.3	23.8	13.6	64
380462j	33.5	28.0	27.7	17.0	65
380462k	26.6	22.6	22.3	13.6	65
380532	35.9	29.0	29.6	18.0	62

OCCURRENCE.—Tuwaiq Mountain Formation: L916, S293, S296.

TYPES.—Holotype: USNM 380462a. Paratypes 380462b–k, 380532.

DISCUSSION.—This species differs from *Bihenithyris barringtoni* Muir-Wood, 1935, in its large size, triangular outline, anteriorly concave dorsal valve and in having its maximum width at the anterior.

The specimen excavated for the loop is about half grown and unfortunately appears to have been broken, nevertheless it is possible to have a fair idea of the complete loop; a half loop is better than no loop.

Arabicella, new genus

TYPE SPECIES.—*Arabicella subpentagonalis*, new species.

DIAGNOSIS.—Large, subpentagonal, ventral valve deeper

than dorsal valve; anterior commissure strongly sulciplicate. Dorsal umbo longitudinally indented. Beak pressed onto dorsal umbo. Foramen small, mesothyridid to permesothyridid.

Interior: Dorsal valve with loop angle moderatly wide, loop 2/5 valve length, 1/3 valve width. Crural processes at or anterior to midloop. Transverse band strongly arched, crest protuberant.

SPECIMENS STUDIED.—110.

GEOLOGIC OCCURRENCE.—Bathonian to Callovian.

ETYMOLOGY.—Latin *arabicus* (Arabian).

DISCUSSION.—This genus in its pentagonal outline and quadrilobate anterior suggests *Arapsothyris*, but that genus has a concave dorsal valve and wider loop than *Arabicella*. Also similar externally to *Arabicella* is *Epithyris* Buckman (1917); the latter has a loop angle wider than that of *Arabicella* and does not have the umbonal depression so characteristic of *Arabicella*.

In its sulcate umbo and strong quadrilobation this genus resembles older forms of *Arapsothyris*, new genus (compare *A. magna*, new species, USNM 380289, Plate 22: figures 13–15) in which the concavity of the dorsal valve is somewhat reduced by age. The loops of the two genera are close and indicate relationship.

Arabicella? costata, new species

PLATE 20: FIGURES 11–13

DIAGNOSIS.—*Arabicella*? with subdued peripheral costae.

DESCRIPTION.—Large, subpentagonal, length and width nearly equal. Maximum width at midvalve. Ventral valve more convex than dorsal valve. Sides rounded, apical angle acute. Anterior commissure sulciplicate. Beak short, wide, erect. Foramen mesothyridid. Symphytium concealed. Surface smooth except for peripheral costation on anterolateral margins.

Ventral valve fairly strongly convex in lateral view, broadly, somewhat angularly domed with long sloping sides in anterior profile. Umbonal, median regions swollen. Sulcus in anterior third, wide, shallow, occupied by broad plica extending nearly to midvalve. Tongue short, bilobed.

Dorsal valve gently convex in side view, with suggestion of anterior half flat or slightly concave. Anterior view forming low dome, slightly elevated medially. Fold defined in anterior third as 2 short subangular costae separated by sulcus forming bilobed anterior.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380426: length 36.4, dorsal valve length 31.2, width 36.0, thickness 18.7, apical angle 87°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1146.

TYPE.—Holotype: USNM 380426.

DISCUSSION.—This species is similar to *Arabicella subplana*, new species, but differs in its rounded outline, less carinate beak, the development of peripheral costae on the flanks, and absence of a dorsal median umbonal depression.

Arabicella ovalis, new species

PLATE 20: FIGURES 30–32, PLATE 21: FIGURES 1–9

DIAGNOSIS.—Narrowly oval *Arabicella* with fairly strongly convex dorsal valve.

DESCRIPTION.—Large, elongate oval, maximum width anterior to midvalve; anterior protuberant, rounded, anterolateral extremities narrowly rounded producing quadrilobate anterior half; apical angle acute. Anterior commissure moderately sulciplicate. Dorsal umbo with median depression extending nearly to midvalve. Beak narrowly rounded to subcarinate, suberect to erect, usually resting on dorsal umbo. Foramen small, permesothyridid. Smooth.

Ventral valve strongly convex with umbonal region most convex in side view. Anterior view forming high narrow dome with steeply sloping sides. Valve swollen from beak to anterior. Sulcus in anterior third with broad median swelling. Tongue short, more or less strongly bilobed.

Dorsal valve gently convex in side view, broadly, moderately domed in anterior profile. Median and umbonal regions swollen; umbo with shallow sulcus reaching nearly to midvalve. Fold low, originating 2/3 valve length from posterior at about point where umbonal sulcus ends. Fold low bounded by low costae with broad depression in between.

Interior: Ventral valve not seen. Dorsal valve with incomplete loop. Cardinal process forming small semielliptical shelf. Socket ridges thin, curved bounding narrow sockets. Outer hinge plates narrow, shallow, dorsally attached with moderately long taper to dorsal side of crural bases. Crural processes long, sharply pointed; anterior to midloop. Lateral bands short, widely bowed. Terminal points moderate. Transverse band imperfect, strongly arched with narrow crest.

LOOP STATISTICS.—USNM 380493 (broken loop): angle = 39°; W1/L1 = 0.67; L1/LD = 0.45; W1/WD = 0.30; a/L1 = 0.55; b/L1 = 0.45; c/L1 = 0.30; d/L1 = 0.25; e/L1 = 0.19; f/L1 = 0.26; g/WD = 0.30; g/W1 = 1.00; h/f = ?; h/L1 = ?; WD/LD = 0.98.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement or not possible to measure from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380292	30.3	26.0	24.7	19.4	80	15.5
380425a	33.5	28.7	27.3	20.0	91	16.7
380543	19.6	17.4	20.5	10.7	90	?
380554	35.5	28.4	31.0	22.0	81	20.4
380560	33.3	27.5	27.5?	21.9	73	?
380561	32.4	26.3	26.5	20.0?	?	17.5

OCCURRENCE.—Dhruma Formation (*Dhrumaites* Zone): S1009, S1436; KK9-97–98, -98; (Atash Member): S1296; KK9-112.

TYPES.—Holotype USNM 380292. Paratypes: USNM

380425a,b, 380493, 380543, 380554, 380560, 380561.

DISCUSSION.—This species differs from *Arabicella subpentagonalis*, new species, in its more ovate form, smaller size, rounded and subdued anterolateral extremities, and more convex dorsal valve. Wider form and stronger anterior folding of *A. subplana*, new species, distinguish that species from *A. ovalis*.

Arabicella subpentagonalis, new species

PLATE 21: FIGURES 13–32

DIAGNOSIS.—strongly pentagonal *Arabicella*.

DESCRIPTION.—Large, elongate pentagonal; maximum width anterior of midvalve. Ventral valve deeper than dorsal valve; Anterior quadrilobate, anterior lateral extremities narrowly rounded to subangular; apical angle acute. Anterior commissure strongly, broadly sulciplicate. Beak narrowly rounded, short, erect to incurved, partially concealing symphytium. Foramen small, mesothyridid to permesothyridid. Smooth.

Ventral valve strongly convex with maximum curvature on umbo in side view; anterior profile forming high narrow dome with sloping sides. Umbonal and median regions swollen, swelling continuing to anterior margin. Sulcus wide, starting one third distance from anterior margin, shallow with broad, raised median elevation forming subangular reentrant in ventral view. Tongue fairly long, sharply bilobed.

Dorsal valve very gently convex in side view, forming broad low dome with abrupt vertical sides in anterior profile. Umbonal, median regions swollen. Umbo with shallow narrow depression usually confined to umbo, rarely continued to midvalve. Fold originating anterior of midvalve, bounded by broad, subangular costae separated by deep sulcus. Flanks narrowly rounded forming distinct lateral lobes.

Interior: Ventral valve not seen. Dorsal valve with small, semielliptical cardinal process. Loop occupying $^2/_5$ valve length, $^1/_3$ valve width. Socket ridges thin, curved; sockets wide. Outer hinge plates very narrow, tapered along dorsal side of crural bases. Crural processes wide, needle-sharp, anterior of midloop. Lateral lamellae bowed; Transverse band strongly arched, crest narrow, protuberant. Terminal points short.

LOOP STATISTICS.—USNM 380492: angle = 42°; W1/L1 = 0.73; L1/LD = 0.42; W1/WD = 0.32; a/L1 = 0.54; b/L1 = 0.46; c/L1 = 0.36; d/L1 = 0.18; e/L1 = 0.21; f/L1 = 0.25; g/WD = 0.31; g/W1 = 0.93; h/f = 0.28; h/L1 = 0.04; WD/LD = 0.99.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380291	38.7	31.3	34.0	24.0	67	23.0
380489	40.0	32.4	33.2	22.5?	70	20.5
380490	31.4	26.5	28.0	19.4	82	17.0
380492	?	34.0	31.4	?	?	?
380508	42.7	32.3	36.5	23.0?	70	23.0
380509a	33.4	28.4	28.8	21.5	82	17.0
380509b	33.5	28.4	29.0	21.5	79	16.5
380544a	25.5	20.5	21.6	14.6	77	12.4

OCCURRENCE.—Dhruma Formation (*Micromphalites* Zone): S743, S1150, S1151; (*Dhrumaites* Zone): S1007, KK9-95–96, 96–97, -97, -97–98, -98, -99; (Atash Member): S1148, S1296, S1478. (Zone not placed): S1450. Upper Dhruma Formation (Zone not placed): S1295. Tuwaiq Mountain Formation: S1712.

TYPES.—Holotype: USNM 380508. Paratypes: USNM 380291, 380427, 380489, 380490, 380491, 380492, 380509a,b, 380544a–c.

DISCUSSION.—This species differs from *Arabicella subplana*, new species, in its more elongate form, generally stronger plication and larger size. It differs from *A. ovalis*, new species, in its larger size, pentagonal shape, generally less strongly convex dorsal valve, and much stronger anterior folding.

Arabicella subplana, new species

PLATE 21: FIGURES 10–12, PLATE 23: FIGURES 28–33

DIAGNOSIS.—Widely pentagonal *Arabicella* with strong sulciplication, dorsal valve nearly flat to slightly concave anteriorly.

DESCRIPTION.—Large, widely subpentagonal, maximum width anterior of midvalve. Ventral valve more convex than dorsal valve. Anterior broadly rounded, sides narrowly rounded. Apical angle variable, mostly near a right angle. Anterior commissure sulciplicate, producing with anterolateral extremities a quadrilobate anterior half. Beak subcarinate, low, erect; Foramen small, permesothyridid. Symphytium hidden. Smooth.

Ventral valve strongly convex with most convexity at umbo in side view; anterior view forming high, narrow dome with long sloping sides. Umbonal and median regions swollen. Sulcus poorly defined, marked by bounding costae with median broad rib or with median part of valve swollen. Tongue short, bilobed.

Dorsal valve very gently convex posteriorly, flat or gently concave anterior in side view. Anterior profile nearly flat often with gentle median depression. Umbo with narrow median depression extending to midvalve or beyond to join sulcus occupying low anterior fold; fold variable marked by low bounding costae or fairly strong ones.

Interior: Ventral valve not seen. Dorsal valve with narrow semielliptical cardinal process. Loop near half valve length(?), $^1/_3$ valve width. Socket plates thin, curved. Outer hinge plates narrow, concave tapered onto dorsal edge of crural bases. Crural processes located at midvalve. Transverse band strongly arched, protuberant.

LOOP STATISTICS.—USNM 380487(broken specimen): an-

gle = 39°; W1/L1 = 0.65; L1/LD = 0.48?; W1/WD = 0.27; a/L1 = 0.50; b/L1 = 0.50; c/L1 = 0.30; d/L1 = 0.20; e/L1 = 0.20; f/L1 = 30; g/WD = 0.25; g/W1 = 1.00; h/f = 0.20; h/L1 = 0.06; WD/LD = 0.86?

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle	Fold width
380427	28.0	22.8	23.7	14.6	78	12.8
380456	29.6	24.0	29.8	15.3	91	15.6
380488b	36.5	28.5	33.9	20.0	85	19.6
380553a	34.6	28.4	32.5	19.4?	88	19.4
380553c	27.0	22.6	26.9	14.7	92	14.0
380553f	24.0	19.3	23.8	12.0	92	?
380553g	19.3	16.8	19.0	10.8	90	?

OCCURRENCE.—Dhruma Formation (*Micromphalites* Zone): S1150, KK9-56; (*Dhrumaites* Zone): S1007, S1200, KK9-95, -95–96, -96–97, -97–98, -98, -99; (Atash Member): S1148, S1296, S1730, KK9-112. Upper Dhruma Formation (Zone not placed): S736.

TYPES.—Holotype: USNM 380488b. Paratypes: USNM 390427, 380456, 380487, 380488a, 380545, 380553a–g.

DISCUSSION.—This species differs from *Arabicella? costata*, new species, in having a sulcate umbo. It differs from *A. subpentagonalis*, new species, in its wider outline, less strong anterior folding and flatter dorsal valve. *Arabicella subplana* is wider than *A. ovalis*, new species, and has a flatter dorsal valve. *Arabicella subplana* is like *Arapsothyris magna*, new species, in its form. The lateral lobes of *A. subplana* are more anterior than those of *Arapsothyris*, which has a concave dorsal valve.

Arapsopleurum, new genus

TYPE SPECIES.—*Arapsopleurum arabicum*, new species.

DIAGNOSIS.—Elongate oval, inequivalve, apical angle acute. Anterior commissure sulciplicate. Foramen large mesothyridid to permesothyridid. Loop 1/2 valve length. Crural processes posterior of midloop.

SPECIMENS STUDIED.—12.

GEOLOGIC OCCURRENCE.—Callovian.

DISCUSSION.—This genus is characterized by its narrowly oval outline and sulciplicate anterior folding with a tendency to develop costation in the ventral sulcus. It differs from *Tanyothyris*, new genus, and *Dissoria*, new genus, in its sulciplicate folding. It is never so numerously costated as *Pleuraloma*, new genus, some specimens of which, are narrowly elongate oval.

Arapsopleurum arabicum, new species

PLATE 23: FIGURES 21–24

DIAGNOSIS.—Large, elongate oval, maximum width slightly anterior to midvalve. Anterior gently rounded; sides gently rounded; apical angle acute. Anterior commissure gently sulciplicate. Beak short, rounded, erect; foramen large mesothyridid. Symphytium partially revealed. Smooth.

Ventral valve moderately convex in side view, with greatest convexity at umbo. Anterior profile forming low rounded dome with short steep slopes. Median region swollen. Sulcus formed in anterior third, shallow, occupied by two low costae extending posteriorly for about 1/3 valve length. Tongue short, trilobed.

Dorsal valve flatly convex in side view, anterior profile forming more rounded and higher dome than that of ventral valve. Median region swollen. Fold visible only in anterior quarter, wide, low, occupied by one low rounded costa.

Interior: Ventral valve not seen. Dorsal valve with thin, bilobed cardinal process. Loop occupying about 1/2 valve length; Socket ridges thin, curved. Outer hinge plates short, narrow, attached dorsally. Crura short; crural processes long, acutely pointed, located posterior of midloop. Terminal points moderately long. Transverse band not seen.

LOOP STATISTICS.—USNM 380463 (only right half of loop preserved): angle narrow; W1/WD = ?; L1/LD = 0.50; W1/WD = ?; a/L1 = 0.45; b/L1 = 0.55; c/L1 = 27; d/L1 = 0.18; e plus f/L1 = 0.55; g/WD = 0.47; g/W1 = ?; WD/LD = 0.83.

MEASUREMENTS (in mm).—USNM 380444: length 28.0, dorsal valve length 22.8, width 21.7, thickness 16.0, apical angle 58°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380444. Paratype: USNM 380463.

DISCUSSION.—This species is most like *P. rotundum*, new species, differing, however, in having a narrower beak, wider, deeper sulcus in the dorsal fold with two incipient costae at the front. It is wider and with more prominent anterior costae than *P. dubium*, new species.

Arapsopleurum dubium, new species

PLATE 23: FIGURES 25–27

DIAGNOSIS.—Large, *Arapsopleurum* with indistinct anterior costation.

DESCRIPTION.—Large, elongate oval, maximum width near midvalve. Anterior truncate, sides gently rounded, apical angle acute. Anterior commissure sulciplicate. Beak fairly long, narrow, strongly labiate, erect. Foramen large, permesothyridid. Smooth except ventral anterior.

Ventral valve moderately convex in side view with most convexity at umbo; anterior profile broadly moderately domed with steep sides. Umbonal region swollen. Sulcus broad,

shallow bounded by a costa on each side reaching to about 1/3 valve length posteriorly. Two costae, low, wide occupy sulcus but do not affect commissure.

Dorsal valve gently convex in side view, roundly domed in anterior profile. Median region gently swollen. Fold defined by 2 short costae reaching about 1/3 valve length toward posterior with broad shallow, naked sulcus between. Sulcus not affected by costae on ventral sulcus.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380496: length 27.6, dorsal valve length 24.0; width 20.6, thickness 16.4, apical angle 50°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPE.—Holotype: USNM 380496.

DISCUSSION.—This species is unlike other *Arapsopleurum* in not having costae in the dorsal sulcus.

Arapsopleurum rotundum, new species

PLATE 23: FIGURES 18–20

DIAGNOSIS.—*Arapsopleurum* with costation restricted to anterior commissure.

DESCRIPTION.—Nearly same size and shape as *A. arabicum*, new species, but differing in having more strongly convex ventral valve, less convex sides, with less pronounced anterior fold, which is confined to the margin of the anterior commissure.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380438: length 26.5, dorsal valve length 21.4, width 20.8, thickness 17.2, apical angle 58°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPE.—Holotype: USNM 380438.

Arapsothyris, new genus

TYPE SPECIES.—*Arapsothyris magna*, new species.

DIAGNOSIS.—Large, pentagonal, inequivalve, ventral valve convex, dorsal valve concave, deeply so in young, less so in adults; dorsal umbo indented; sulciplicate, strongly quadrilobate. Loop wide, occupying 2/5 valve length and width. Crural processes anterior of midloop.

SPECIMENS STUDIED.—38.

GEOLOGIC OCCURRENCE.—Bathonian to Callovian.

ETYMOLOGY.—Greek *arapso* (Arab).

DISCUSSION.—This genus has obvious affinities with *Arabicella*, sharing several characters: sulcate dorsal umbo, quadrilobate anterior, carinate beak and small foramen. It differs in its concave dorsal valve, which is in contrast to the convex to swollen umbonal region of *Arabicella*. Young specimens have a deeply concave dorsal valve, which becomes less concave with age, actually becoming slightly convex.

Arapsothyris angustata, new species

PLATE 23: FIGURES 12–17

DIAGNOSIS.—Long, narrow, large *Arabicella*.

DESCRIPTION.—Large, narrowly subpentagonal, maximum width at midvalve, anterior nasute; lateral margins rounded, apical angle acute. Anterior commissure narrowly sulciplicate. Beak narrow, fairly long, labiate, subcarinate, incurved. Foramen small, permesothyridid. Symphytium concealed. Smooth.

Ventral valve strongly convex in side view with narrowly rounded umbo; lateral view narrowly strongly domed with long steep slopes. Umbo, median, anterior regions narrowly swollen to subcarinate. Sulcus shallow; bounding costae narrowly rounded; sulcus occupied by median costa extending nearly to midvalve. Tongue moderately long bilobed.

Dorsal valve gently convex in side view, broadly concave in anterior profile with short vertical sides. Umbonal and median regions sulcate. Fold about 1/3 valve length, defined by bounding costae separated by shallow depression.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement and no measurement possible from imperfect specimen, respectively.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380434	42.0	35.0	29.0	25.5?	75	17.4
380454a	45.7	37.3	30.0	25.0	67	16.0
380454b	39.4	33.0	27.3	19.5?	78	?

OCCURRENCE.—Upper Dhruma Formation (Zone not placed): S1257, S1471. Tuwaiq Mountain Formation: S1253, S1460.

TYPES.—Holotype: USNM 380454a. Paratypes: USNM 380434, 380454b.

DISCUSSION.—The narrow, elongate form of this species is distinctive, only possibly to be confused with *Stenorina*, new genus, which is still narrower with a larger foramen, different beak, stronger anterior folding, and smaller size.

Arapsothyris magna, new species

PLATE 22: FIGURES 6–20

DIAGNOSIS.—Large, wide *Arapsothyris*.

DESCRIPTION.—Large, pentagonal; maximum width at about midvalve. Anterior narrowly, gently rounded, sides narrowly rounded, apical angle approximating a right angle. Posterolateral margins gently concave. Ventral valve strongly convex, dorsal valve more or less strongly concave, deeply concave in young, less so in old adults. Anterior commissure sulciplicate. Beak subcarinate, narrow, short, erect. Foramen small,

permesothyridid. Surface with closely spaced lines of growth.

Ventral valve strongly convex in side view, narrowly domed with flattish, long steeply sloping sides in anterior profile. Umbonal and median regions narrow swollen, swelling extending to anterior between 2 broad costae marking position of sulcus.

Dorsal valve deceptively convex in side view, broadly concave in anterior profile. Umbo narrowly sulcate, sulcus extending into broad concavity extending to anterior. Fold developed at anterior of concave valve, visible in anterior third as pair of broad costae separated by shallow depression.

Interior: Ventral valve not seen. Dorsal valve with small, semielliptical cardinal process. Loop wide, occupying 2/5 valve length, and width. Socket ridges thin, curved; outer hinge plates short, narrow; crural processes long, sharply pointed, located anterior of midloop. Lateral lamellae short, flared laterally. Transverse band strongly arched, wide at base narrowed distally to form narrow, protuberant crest. Terminal points short.

LOOP STATISTICS.—USNM 380485: angle = 50°; W1/L1 = 0.91; L1/LD = 0.37; W1/WD = 0.40; a/L1 = 0.53; b/L1 = 0.47; c/L1 = 0.24; d/L1 = 0.29; e/L1 = 0.28; f/L1 = 0.19; g/WD = 0.29; g/W1 = 0.85; h/f = 0.45; h/L1 = 0.09; WD/LD = 1.15.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates no measurement possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*	*Fold width*
380289	44.6	38.0	43.0	27.3	86	26.7
380432	46.4	38.2	41.4	21.0	88	?
380531	44.0	37.6	38.4?	20.4	82	27.3
380542	32.3	25.6	31.0	?	83	?

OCCURRENCE.—Dhruma Formation (*Micromphalites* Zone): S743, S1496; (*Dhrumaites* Zone): S1007, S1200; (Atash Member): S1478, S1730. Upper Dhruma Formation (Zone not placed): 736, S1235, S1469. Tuwaiq Mountain Formation: S1146.

TYPES.—Holotype: USNM 380289. Paratypes: USNM 380432, 380485, 380531, 380542, 380545.

DISCUSSION.—This species is larger and wider than *Arapsothyris angustata*, new species. It resembles '*Terebratula*' *superstes* Douvillé (1916:63, pl. 7: fig. 9), which is a large quadrilobate form from the Bathonian of the Sinai Peninsula, Egypt. The Saudi Arabian species differs in having a narrower, subcarinate beak, shorter and concave posterolateral margins, maximum width more posterior, and the dorsal valve more deeply concave.

Avonothyris Buckman, 1917

Avonothyris? species

PLATE 23: FIGURES 1–3

DESCRIPTION.—Large, elongate oval, maximum width anterior to midvalve; ventral valve deeper than dorsal valve; anterior truncate; sides moderately rounded, apical angle acute. Anterior commissure strongly sulciplicate. Beak short, narrowly rounded, labiate, partially concealing symphytium; beak ridges strong. Foramen small, permesothyridid. Surface with concentric lines of growth, otherwise smooth.

Ventral valve moderately, evenly convex in lateral view, broadly, moderately domed in anterior view with short steep flanks. Median and umbonal regions swollen. Sulcus in anterior third, bounded by strong narrowly rounded costae, occupied by broad plication extending for 1/3 valve length. Tongue long, angularly bilobed.

Dorsal valve flatly convex in side view, forming low wide dome with steep sides, steeper than those of ventral valve in anterior profile. Valve medially swollen. Fold at anterior third, wide, occupying half shell width, bounded by narrowly rounded costae with short deep sulcus between.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380304: length 43.2, dorsal valve length 36.6, width 35.2, thickness 24.3, apical angle 91°.

OCCURRENCE.—Dhruma Formation (Zone not placed): S1156.

SPECIMEN EXAMINED.—USNM 380304.

DISCUSSION.—The exterior of this species is very close to that of *Avonothyris corpulenta* Buckman (1917, pl. 21: fig. 12a) in its length-width relationships. The fold of *A. corpulenta* is slightly wider than that of the Saudi Arabian specimen. The beak characters are close. Buckman does not figure side or anterior views of his species. This is a much larger species than most of those assigned to *Avonothyris*. The stratigraphic level of this brachiopod in the Dhruma Formation is so uncertain that its name does not appear on Figure 3.

Bihenithyris Muir-Wood, 1935

The species here referred to *Bihenithyris* that display loops all agree in the details of the loops. Some of the species in their interiors are close to *Terebratula subsella* Leymerie now referred to *Habrobrochus* Cooper (1983:87). The loop of *Bihenithyris barringtoni* Muir-Wood (1935) is not known in detail, because Muir-Wood's sections do not go beyond the crural processes. If the loop of the type species, *B. barringtoni*, should prove identical with those here described, *Habrobrochus* then would be separated from *Bihenithyris* on its folding and shape. The '*subsella*' type of terebratulid, widely identified

in the Late Jurassic, has less strongly developed folding and different shape than the species described herein and also from Muir-Wood's type species, *B. barringtoni*. *Bihenithyris* sensu stricto is more strongly folded and with pronounced triangular form. These shape and folding differences serve as a distinction between the two genera, the name *Habrobrochus* serving for those species with subdued folding and elongate triangular form, such as *H. amygdaloideus*, new species. This species is close to the specimens from Israel referred by Cooper to *Bihenithyris* (1983:60, pl. 31: figs. 17–23): *B.* cf. *weiri* Muir-Wood (1935) and *B.* aff. *B. barringtoni* Muir-Wood, both specimens of which are much more subdued in their folding than Muir-Wood's type, *B. barringtoni*. Specimens called *Terebratula subsella* (Auct. not Leymerie) are probably referable to *Habrobrochus*.

Bihenithyris? abnormis, new species

PLATE 23: FIGURES 4–8

DIAGNOSIS.—Small, triangular with long strong median costa on ventral valve.

DESCRIPTION.—Small, triangular, longer than wide, maximum width anterior to midvalve. Anterior truncate, anterolateral extremities narrowly rounded; posterolateral margins straight, forming acute angle. Anterior commissure episulcate. Beak low, rounded, suberect. Foramen large, mesothyridid; symphytium partially concealed. Surface smooth.

Ventral valve moderately convex in side view, forming low dome with shallow median depression in anterior profile. Umbonal and median regions swollen. Sulcus originating posterior of midvalve, deep, occupied by strong, long, rounded median costa extending almost to umbo. Sides abrupt, precipitous.

Dorsal valve moderately deep, gently convex in side view, roundly domed with steeply sloping sides in anterior profile. Fold originating at midvalve, narrow, composed of 2 narrowly rounded costae extending to midvalve; costae bounding deep, narrow sulcus.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380511: length 18.0, dorsal valve length 14.9, width 15.6, thickness 11.4, apical angle 49°.

OCCURRENCE.—Tuwaiq Mountain Formation: L916 [= S154].

TYPE.—Holotype USNM 380511.

DISCUSSION.—This is the smallest species referred to *Bihenithyris*. It differs from *B. quadrilobata*, new species, which it approaches, in smaller size, less quadrate anterior and narrower fold. The described specimen is the only one in the collection.

Bihenithyris deformata, new species

PLATE 24: FIGURES 1–8

DIAGNOSIS.—Large widely triangular strongly sulciplicate *Bihenithyris*.

DESCRIPTION.—Moderately large, triangular, maximum width at anterior; sides anteriorly narrowly rounded, posterolateral margins nearly straight forming an acute angle. Slightly longer than wide. Anterior commissure sulciplicate. Beak short, rounded, slightly labiate. Foramen large, mesothyridid. Surface smooth.

Ventral valve moderately convex in side view broadly convex in anterior view. Medially swollen. Sulcus starting anterior to midvalve, bounding costae short narrowly rounded. Sulcus occupied by strong fold extending posteriorly to midvalve.

Dorsal valve flatly convex in side view, forming low arch in anterior profile. Fold narrow, defined by two short, narrowly rounded costae separated by deep sulcus. Flanks moderately steep.

Interior: Ventral valve not seen. Dorsal valve with large, wide cardinal process; loop about 1/2 valve length, 2/3 valve width. Hinge plates narrow, dorsally attached by long taper. Crural processes at half loop length, thick sharply pointed. Lateral lamellae short, laterally bowed. Transverse band strongly, narrowly arched, somewhat protuberant. Terminal points moderately long.

LOOP STATISTICS.—USNM 380479: angle = 33°; W1/L1 = 0.53; L1/LD = 0.52; W1/WD = 0.38; a/L1 = 0.50; b/L1 = 0.50; c/L1 = 0.36; d/L1 = 0.14; e/L1 = 0.18; f/L1 = 0.32; g/WD = 0.35; g/WL = 0.94; h/f = 0.30; h/L1 = 0.04; WD/LD = 0.85.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380435a	26.0	21.4	24.0	14.6?	73
380435c	30.0	26.0	26.6	15.0?	77

OCCURRENCE.—Tuwaiq Mountain Formation: S1467.

TYPES.—Holotype: USNM 380435a. Paratypes: USNM 380435b,c, 380479.

DISCUSSION.—The few specimens of this species have all suffered some deformation. The specimen of interior is not deformed. This species is larger and wider than *B. mediocostata*, new species, which has a narrower beak, stronger costae, and more angulated anterolateral extremities.

Bihenithyris mediocostata, new species

PLATE 23: FIGURES 9–11

DIAGNOSIS.—*Bihenithyris* of medium size with angulated anterolateral extremities.

DESCRIPTION.—Medium, pentagonal, ventral valve deeper than dorsal valve. Maximum width anterior of midvalve. Anterior subtruncate; anterolateral extremities angulated; apical angle acute. Anterior commissure strongly sulciplicate.

Beak massive, rounded, erect. Foramen large, mesothyridid. Smooth.

Ventral valve moderately convex in side view with maximum convexity at umbo. Anterior profile forming low dome with narrow median elevation. Umbonal and median regions swollen. Sulcus starting at about midvalve, shallow, forming bilobed tongue. Sulcus occupied by costae extending posterior of midvalve. Sides precipitous.

Dorsal valve nearly flat in side view, forming low dome in anterior view. Fold originating just anterior to midvalve, formed of two strong costae separated by deep groove extending nearly to midvalve.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380204: length 25.1, dorsal valve length 20.8, width 20.1, thickness 13.0, apical angle 47°.

OCCURRENCE.—Tuwaiq Mountain Formation: L916 [= S154].

TYPE.—Holotype: USNM 380204.

DISCUSSION.—This species is distinguished from *Bihenithyris barringtoni* Muir-Wood (1935) by its smaller size, lesser development and more anterior position of its angulated anterolateral extremities, flatter dorsal valve, and the strong ventral median costa. It differs from *B. quadrilobata*, new species, in its less incurved beak and more pronounced anterolateral extremities. It is smaller and narrower than *B. deformata*, new species.

Bihenithyris quadrilobata, new species

PLATE 24: FIGURES 28–39

DIAGNOSIS.—Small to medium strongly folded *Bihenithyris* with strongly incurved beak.

DESCRIPTION.—Small to medium, subpentagonal, longer than wide; maximum width anterior of midvalve. Anterior truncate, each side with narrow lobe; apical angle acute. Ventral valve deeper than dorsal valve. Lateral commissure sharply curved ventrally at anterior; anterior commissure sulciplicate. Beak in adult strongly incurved over dorsal umbo concealing symphytium. Foramen large, mesothyridid. Surface with strong concentric lines of growth.

Ventral valve gently convex in anterior profile with umbonal region narrowly curved. Anterior view forming gently rounded, steepsided dome often with narrow elevated median costa. Median and umbonal regions swollen. Sulcus in anterior half, fairly deep, bounded by narrow costae and occupied by narrow median costa extending to midvalve. Tongue long, forked.

Dorsal valve nearly flat in side view, forming flattened dome in anterior view. Fold consisting of 2 subangular costae separated by narrow deep sulcus.

Interior: Ventral valve not seen. Dorsal valve with small semielliptical cardinal process. Loop occupying nearly 1/2 valve length, not quite 1/4 valve width. Socket ridges thin; outer hinge plates narrow, concave, dorsally attached; cardinal process broad, bluntly pointed, slightly approximate, located slightly anterior of midloop. Lateral lamellae short, bowed slightly laterally. Transverse band thick at base, thin on crest, protuberant, nearly horizontal. Terminal points moderate.

LOOP STATISTICS.—USNM 380433: angle = 30°; W1/L1 = 0.53; L1/LD = 0.48; W1/WD = 0.24; a/L1 = 0.53; b/L1 = 0.47; c/L1 = 0.33; d/L1 = 0.20; e/L1 = 0.27; f/L1 = 0.20; g/WD = 0.33; g/W1 = 1.37; h/f = 0.33; h/L1 = 0.03; WD/LD = 1.00.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380205a	22.5	16.0	18.9	11.8	59
380205b	19.2	15.0	16.8	11.0	61
380205c	18.0	14.6	15.2	10.0	66
380205d	16.2	11.9	13.0	9.0	53
380205e	24.6	18.8	20.0	13.7	72

OCCURRENCE.—Upper Dhruma Formation (Atash Member): KK9-112.

TYPES.—Holotype: USNM 380205a. Paratypes: USNM 380205b-e, 380433.

DISCUSSION.—This is a small species that differs from most other *Bihenithyris* in its strong anterior plication and the strongly lobed anterolateral region. It is about the same size as *B. mediocostata*, new species, but is more strongly quadrate anteriorly. *B. abnormis*, new species, is a smaller species differing from *B.? quadrilobata* in its triangular form and subdued anterolateral extremities.

Bihenithyris simulans, new species

PLATE 22: FIGURES 1–5

DIAGNOSIS.—About medium size, narrowly sulciplicate *Bihenithyris*.

DESCRIPTION.—Medium, widely ovoid maximum width anterior to midvalve. Ventral valve more convex than dorsal valve. Anterior rounded to slightly nasute, sides rounded; apical angle acute. Anterior commissure narrowly sulciplicate. Beak short, narrowly rounded. Foramen large, mesothyridid. Symphytium partially concealed. Smooth.

Ventral valve gently convex in side view, most convex in umbonal region; anterior profile a gentle arch with moderately sloping sides. Umbonal and median regions swollen. Sulcus shallow, wide in anterior half only, occupied by single narrowly rounded costa. Tongue long, slightly bilobed.

Dorsal valve nearly flat in side view, forming low dome in anterior view. Median region gently swollen. Fold consisting of two short costae separated by short, narrow furrow.

Interior: Ventral valve not seen. Dorsal valve with small, thin semielliptical cardinal process. Loop longer than wide, occupying almost 2/5 valve length, about 1/3 valve width.

Socket ridges thin; outer hinge plates narrow, dorsally attached. Crural processes at midloop, long, acute. Lateral lamellae bowed laterally; transverse band strongly arched, nearly horizontal with flattened crest occupying about 1/3 loop width.

LOOP STATISTICS.—USNM 380494b: angle = 40°; W1/L1 = 0.67; L1/LD = 0.38; W1/WD = 0.29; a/L1 = 0.50; b/L1 = 0.50; c/L1 = 0.33; d/L1 = 0.17; e/L1 = 0.22; f/L1 = 0.28; g/WD = 0.31; g/W1 = 1.08; h/f = 0.28; h/L1 = 0.07; WD/LD = 0.88.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380424	23.6	19.2	20.1	13.0	68
380494a	23.4	18.6	19.5	12.7	62
380547	24.1	19.4	20.8	12.5	64

OCCURRENCE.—Upper Dhruma Formation (Zone not placed): S1469. Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380494a. Paratypes: USNM 380424, 380494b, 380547.

DISCUSSION.—*Bihenithyris simulans* does not have the strong anterior sulciplication of *B. barringtoni* Muir-Wood (1935) and *B. deformata*, new species.

Bihenithyris triangulata, new species

PLATE 24: FIGURES 24–27

DIAGNOSIS.—Strongly biconvex triangular *Bihenithyris*.

DESCRIPTION.—Medium, strongly triangular; maximum width at anterior. Anterior broadly rounded, posterolateral extremities narrowly rounded, anterolateral margins straight forming acute angle. Valves nearly equally deep and convex. Anterior commissure episulcate. Beak short, truncated, not projecting at about level of dorsal umbo, labiate. Foramen small, permesothyridid. Symphytium concealed.

Ventral valve gently convex in side view, broadly domed with short sloping sides in anterior profile. Sulcus broad, shallow, defined in anterior third, occupied by short, narrow costa. Tongue short, narrow, bilobed.

Dorsal valve gently convex in side view, most convex at umbo; strongly, narrowly domed with long sloping sides in anterior view. Fold of 2 costae starting slightly posterior of midvalve, narrow, moderately elevated.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380530: length 24.0, dorsal valve length 24.2, width 22.5, thickness 17.6, apical angle 76°, fold width 13.2.

OCCURRENCE.—Dhruma Formation (Zone not placed): S1790.

TYPE.—Holotype: USNM 380530.

DISCUSSION.—The single specimen has the form of *Bihenithyris* with its prominent anterolateral lobes. This one differs from all the others in the recessive character of the beak, which scarcely protrudes beyond the dorsal umbo and is strongly truncated.

Bihenithyris species

PLATE 24: FIGURES 9–13

These Saudi Arabian specimens and Muir-Wood's species strongly deviate in exterior details from the type species, *B. barringtoni* Muir-Wood (1935:111, figs. 12, 13, pl. 12: figs. 7a–c). The specimens are narrowly elongate oval, not wide anterolaterally like the type, but are narrowed at the anterior where they are sulciplicate. The apical angle is acute. The ventral valve is fairly strongly convex, while the dorsal valve is nearly flat. The foramen is large, mesothyridid in a low rounded beak. the surface is smooth.

Interior: The ventral valve interior was not seen. The loop of the dorsal valve has a small semielliptical cardinal process. The loop extends for 2/5 valve length and 1/3 valve width. The socket ridges are thin and the outer hinge plates narrowly concave, tapered and attached dorsally. The crural processes are slightly anterior of midloop. The lateral lamellae are short and bowed laterally. The transverse band is nearly horizontal, thick at the base, thinned on the arch, strongly protuberant.

LOOP STATISTICS.—USNM 380478b: angle = 34°; W1/LD = 0.68; L1/LD = 0.39?; W1/WD = 0.30; a/L1 = 0.53; b/L1 = 0.47; c/L1 = 0.29; d/L1 = 0.24; e/L1 = 0.22; f/L1 = 0.25; g/WD = 0.40; g/W1 = 1.22; h/f = 0.25; h/L1 = 0.06; WD/LD = 0.88?

MEASUREMENTS (in mm).—USNM 380478a (imperfect specimen): length 25.0, dorsal valve length 21.0; width 18.0?, thickness 14.0; apical angle 57°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1467.

TYPES.—Hypotypes: USNM 380478a,b.

DISCUSSION.—This species is narrow like *B. weiri* Muir-Wood, 1935 differing in being not so nasute anteriorly as the African species.

Dolichobrochus Cooper, 1983

Dolichobrochus? ovatus, new species

PLATE 26: FIGURES 22–27

DIAGNOSIS.—Narrowly ovate *Dolichobrochus?* with poorly developed sulciplication.

DESCRIPTION.—About medium, elongate oval, maximum width slightly anterior of midvalve. Anterior narrowly rounded, sides gently rounded, apical angle acute. Anterior commissure incipiently sulciplicate. Beak short, narrow, labiate, concealing symphytium. Foramen large, mesothyridid. Surface marked by concentric lines of growth.

Ventral valve moderately convex in side view, forming narrowly rounded, steep-sided dome in anterior view. Umbonal and median regions swollen. Anterior third flattened to form

short broadly rounded tongue.

Dorsal valve gently convex in side view, forming narrow, high steep-sided dome like that of ventral valve in anterior profile. Median region swollen, swelling extending into poorly defined fold bounded by indistinct, short costae.

Interior: Ventral valve not seen. Dorsal valve with fairly long loop occupying slightly more than $^2/_5$ valve length, less than $^1/_3$ valve width. Loop twice as long as wide. Outer hinge plates narrow, tapered, dorsally attached. Crural processes small, bluntly pointed, located well anterior of midloop. Transverse band, thin, narrowly arched, nearly horizontal protuberant, crest narrow.

LOOP STATISTICS.—USNM 380495a: angle = 29°; W1/L1 = 0.53; L1/LD = 0.42; W1/Wd = 0.24; a/L1 = 0.59; b/L1 = 0.41; c/L1 = 0.34; d/L1 = 0.25; e/L1 = 0.22; f/L1 = 0.19; g/WD = 0.31; g/W1 = 1.29; h/f = 0.30; h/L1 = 0.08; WD/LD = 0.92.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380422	22.3	17.8	17.1	13.7	63
380495a	24.2	20.0	18.0	13.9	56
380548	22.3	18.2	16.7	12.4	63

OCCURRENCE.—Tuwaiq Mountain Formation: S154, S296.

TYPES.—Holotype: USNM 380495a. Paratypes: 380422, 380495b, 380548.

DISCUSSION.—This species is placed in *Dolichobrochus* because of the great length of the loop from beak to crural processes (a/L1 = 0.59). The species is more elongate and with less prominent sulciplication than that of *D. excavatus* (E. Deslongchamps) figured by Cooper (1983, pl. 31: figs. 1–3).

Dorsoplicathyris Almeras, 1971

Dorsoplicathyris? species

PLATE 25: FIGURES 38–42

DESCRIPTION.—Large, elongate oval with gently curved nearly parallel sides; anterior rounded; apical angle acute. Ventral valve deeper than dorsal valve. Anterior commissure narrowly sulciplicate. Beak low, rounded, erect; foramen large, permesothyridid. Smooth.

Ventral valve gently convex in side view, forming low dome with rounded precipitous sides in anterior profile. Median and umbonal regions swollen. Anterior third flattened to form broad shallow sulcus occupied by low broad swelling that disappears before midvalve. Tongue short with slight median indentation.

Dorsal valve flatly convex in side view, forming broad dome with steeply sloping sides in anterior profile. Umbonal region swollen, swelling continued anteriorly as low fold at anterior third; fold consisting of low broad costae separated by shallow sulcus.

Interior: Ventral valve with short, excavate pedicle collar. Dorsal valve with thin socket ridges, short narrow concave hinge plates dorsally attached. Crura short, crural processes located opposite anterior margin of outer hinge plates.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380417	32.8	26.6	23.6	17.0	75
380418	33.4	28.7	22.3	18.5	?

OCCURRENCE.—Hanifa Formation: S625, S1050, S1052.

TYPES.—Hypotypes: USNM 380417, 380418.

DISCUSSION.—These specimens suggest *Dorsoplicathyris dorsoplicata* (E. Deslongchamps, 1856) in size and fold but have less rounded sides and narrower anterior than that of Almeras' neotype (1971, pl. 84: figs. 11b–d). It is also similar to *D. prolifera* (Boullier, 1976). Again its sides are less rounded and the anterior less conspicuously folded. In the absence of more knowledge of the loop this generic assignment must remain tentative.

Ectyphoria, new genus

TYPE SPECIES.—*Ectyphoria inflata*, new species.

DIAGNOSIS.—Much inflated, resembling *Rugitela* with carinate ventral umbo, sulcate dorsal umbo.

DESCRIPTION.—Medium, valves strongly inflated, subequivalve; lateral commissure sigmoidal; foramen small, oval; anterior commissure gently biplicate. Ventral umbo strongly carinate; dorsal umbo with fairly deep furrow extending to midvalve. Surface smooth.

Ventral interior without dental plates. Dorsal valve with virgate hinge plates, bilobed cardinal process and long loop with long crural processes. Transverse band not known.

SPECIMENS STUDIED.—10.

GEOLOGIC OCCURRENCE.—Late Bathonian to Callovian.

ETYMOLOGY.—Greek *ektyphos* (puffed up), in allusion to the strongly swollen valves.

DISCUSSION.—At first glance this brachiopod suggests the very plump *Rugitela* Muir-Wood, 1936; however, it lacks dental plates and it has a divided hinge plate, normal for a terebratulacean. It also suggests an unusually stout *Arabicella*, which also has a carinate ventral umbo and a sulcate dorsal umbo. *Ectyphoria* differs strongly, however, in its narrowly compact form, strongly carinate ventral umbo, stout swollen valves, presence of a bilobed cardinal process, and less strongly biplicate anterior commissure.

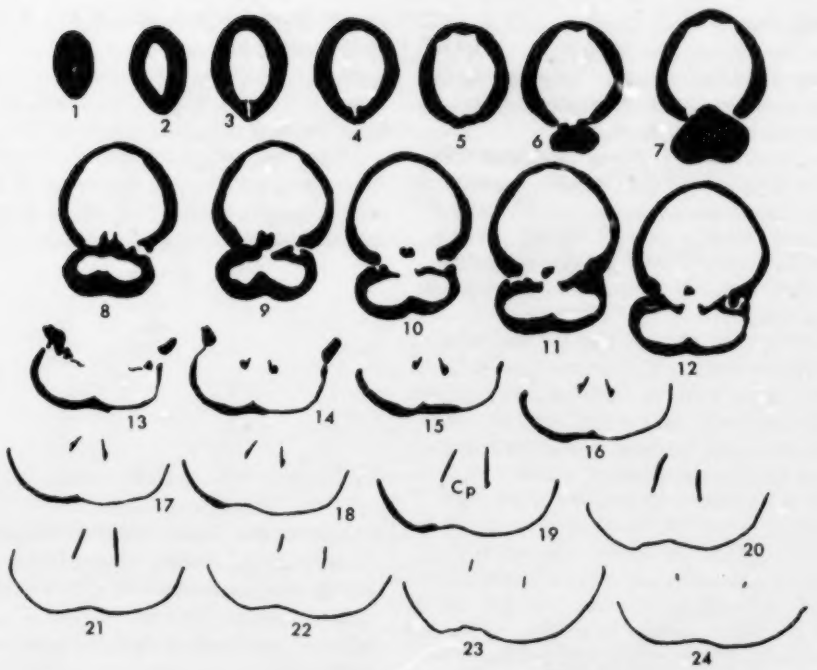

FIGURE 36.—*Ectyphoria inflata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.3(0.3); 2, 0.6(0.9); 3, 0.7(1.6); 4, 0.3(1.9); 5, 0.4(2.3); 6, 0.2(2.5); 7, 0.4(2.9); 8, 0.4(3.3); 9, 0.1(3.4); 10, 0.2(3.6); 11, 0.2(3.8); 12, 0.2(4.0); 13, 0.3(4.3), 14, 0.3(4.6); 15, 0.4(5.0); 16, 0.2(5.2); 17, 0.4(5.6), 18, 0.2(5.8); 19, 0.4(6.2) (Cp = crural process); 20, 0.5(6.7); 21, 0.3(7.0); 22, 0.3(7.3); 23, 0.4(7.7); 24, 0.3(8.0). Loop incomplete; approximately ×2; length of dorsal valve, incomplete 17.0 mm; USNM 380661; Locality S1148.

Ectyphoria inflata, new species

FIGURE 36; PLATE 20: FIGURES 14–19, 27–29

DIAGNOSIS.—Medium with strongly inflated valves, sulcate dorsal umbo and carinate ventral umbo; bilobed cardinal process.

DESCRIPTION.—Medium, small, maximum width anterior to midvalve. Valves subequal in depth. Anterior and sides rounded; apical angle acute. Anterior commissure rectimarginate to sulciplicate. Beak carinate, short, incurved. Foramen small to minute, permesothyridid. Smooth.

Ventral valve strongly convex, most convex umbonally in side view; strongly domed with steep sides anterior profile. Valve narrowly swollen from beak to anterior. Commissures damaged.

Dorsal valve strongly convex, most so in posterior half, somewhat flattened anteriorly in side view. Anterior profile forming high narrow dome with steep sides. Umbonal region swollen, with narrow, fairly deep groove extending to midvalve where it disappears.

Interior: See generic definition.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380405	25.7?	22.3	21.0	19.5	76
380413	26.5	23.0	22.3	21.8	84
380431	27.3	23.4	23.5	18.4	77

OCCURRENCE.—Dhruma Formation (*Dhrumaites* Zone): S1436; KK9-96–97, -98; (Atash Member): S1148; KK9-112; (probably Hisyan Member): S1615.

TYPES.—Holotype: USNM 380413. Paratypes: USNM 380405, 380431, 380661.

DISCUSSION.—This species apes the genus *Rugitela*, a plump zeilleriacean, in its carinate beak, very small foramen, and greatly swollen dorsal valve with its longitudinally indented dorsal umbo. Its lack of dental plates separates it emphatically

from the Zeilleriacea. It differs from species of *Arabicella* in its extremely swollen narrow valves, smaller size and more modest folding of the anterior.

Glyphisaria Cooper, 1983

Glyphisaria? divergens, new species

PLATE 26: FIGURES 4–9, PLATE 28: FIGURES 10–12

DIAGNOSIS.—Small *Glyphisaria?* with narrow fold.

DESCRIPTION.—Roundly subpentagonal, longer than wide, ventral valve deeper than dorsal valve. Maximum width near midvalve. Anterior margin narrowly rounded, sides broadly rounded; apical angle acute. Anterior commissure narrowly uniplicate. Beak short, slightly labiate, partially concealing symphytium. Foramen large mesothyridid. Smooth.

Ventral valve gently convex in side view, moderately, broadly domed in anterior profile. Umbonal and median regions swollen. Anterior flattened forming narrow sulcus visible in anterior quarter. Tongue long, narrowly rounded.

Dorsal valve flatly convex in side view forming broad, moderately convex dome about like that of ventral valve. Median region swollen, swelling extending to short low fold occupying anterior third.

Interior: Ventral valve not well preserved. Dorsal valve with small semielliptical shelf-like cardinal process. Loop occupying 2/5 valve length, nearly 1/3 valve width. Socket ridges thin, outer hinge plates narrow, concave with long taper on dorsal side of crural bases. Crural processes long slender, incurved ventrally, located just anterior to midloop. Lateral lamellae short, bowed laterally. Transverse band thick at base, thinning on crest which occupies about 1/5 loop width. Transverse band nearly horizontal protuberant.

LOOP STATISTICS.—USNM 380296: angle = 39°; W1/L1 = 0.65; L1/Ld = 0.40; W1/WD = 0.27; a/L1 = 0.53; B/L1 = 0.47; c/L1 = 0.0.29; d/L1 = 0.24: e/L1 = 0.26; f/L1 = 0.21; g/WD = 0.27; g/W1 = 1.00; h/f = 0.23; h/L1 = 0.05; WD/LD = 0.95.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380282a	26.7	22.0	22.8	13.6	84
380296	25.0	21.0	20.0	?	73

OCCURRENCE.—Tuwaiq Mountain Formation: S459. Hanifa Formation: KK10-25.

TYPES.—Holotype: USNM 380282a. Paratypes: USNM 380282b,c, 380296, 380638.

DISCUSSION.—This species is tentatively placed in *Glyphisaria* because of its uniplicate anterior commissure and the resemblance of its loop to that of *G. uniplicata* Cooper (1983). This species is much less robust, smaller, and more narrowly uniplicate than the type species from France.

This species is similar in its exterior to the species of *Turkmenithyris* Prosorovskaya (1962) in its rectimarginate folding. Its loop is, however, quite different from that of the Turkoman genus according to Prosorovskaya's serial sections and reconstruction. The loop of her species is shorter, wider, and with the crural processes much more posterior than those of the Saudia Arabian species.

Glyphisaria? species

PLATE 26: FIGURES 1–3

A narrowly ovate specimen with maximum width anterior of midvalve is placed here because of its uniplicate anterior commissure. It differs from *G.? divergens*, new species, in its exterior form, narrower fold, and its narrowly swollen dorsal valve.

MEASUREMENTS (in mm).—USNM 380428: length 24.0, dorsal valve length 20.5, width 19.2, thickness 15.3, apical angle 77°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1702.

SPECIMEN EXAMINED.—USNM 380428a.

Gyrosina Cooper, 1983

Gyrosina? ovata, new species

PLATE 25: FIGURES 31–37

DIAGNOSIS.—Elongate *Gyrosina*.

DESCRIPTION.—Medium, ovoid, maxium width anterior to midvalve. Anterior rounded, sides broadly rounded, apical angle acute. Anterior commissure sulciplicate. Beak short, suberect, narrowly rounded, labiate. Foramen large, mesothyridid. Smooth.

Ventral valve gently convex in lateral view, umbo narrowly curved in side view. Anterior profile forming low rounded dome with sloping sides. Median region swollen. Sulcus short, seen only in anterior quarter, occupied by wide rounded elevation. Tongue short, gently bilobed.

Dorsal valve flatly convex in side view, forming low dome with moderately sloping sides in anterior profile. Fold at anterior quarter defined by 2 short costae separated by short deep sulcus.

Interior: Ventral valve not seen. Dorsal valve with small semielliptical cardinal process; loop fairly wide, in length about 2/5 valve length, 1/3 valve width. Socket ridges thin; outer hinge plates short, narrow, dorsally attached. Crural processes located slightly posterior of midloop. Lateral lamellae short, bowed laterally. Transverse band wide at base, strongly arched, nearly horizontal, strongly protuberant. Terminal points short.

LOOP STATISTICS.—USNM 380473b: angle = 36°; W1/L1 = 0.67; L1/LD = 0.42; W1/WD = 0.33; a/L1 = 0.48; b/L1 = 0.52; c/L1 = 0.31; d/L1 = 0.17; e/L1 = 0.24; f/L1 = 0.28; g/WD

= 0.35; g/W1 = 1.07; h/f = 0.25; h/L1 = 0.07; WD/LD = 0.85.

MEASUREMENTS (in mm).—USNM 380473a: length 28.1, dorsal valve length 23.2, width 21.4; thickness 15.0, apical angle 68°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380473a. Paratype: USNM 380473b.

DISCUSSION.—The loop of this species agrees with that of *Gyrosina rotunda* Cooper (1983), type of the genus. *G.? ovata* is more elongate, with narrower beak and less rounded outline.

Gyrosina? species

PLATE 26: FIGURES 31–34

DESCRIPTION.—A single specimen displaying a good loop is referred here. The specimen is sulciplicate with fairly strong narrow costae on dorsal valve. Ventral valve not known.

The loop occupies $^2/_3$ valve length and more than $^1/_3$ valve width. The cardinal process is a thin, semielliptical shelf. The outer hinge plates are narrow, concave, short, and dorsally attached. The crural processes are acute and located at about midloop. The lateral lamellae are bowed laterally. The transverse band is narrow, arched moderately from the horizontal with narrow crest which is protuberant.

LOOP STATISTICS.—USNM 380475: angle = 41°; W1/L1 = 0.78; L1/LD = 0.42; W1/WD = 0.35; a/L1 = 0.50; b/L1 = 0.50; c/L1 = 0.39; d/L1 = 0.11; e/L1 = 0.22; f/L1 = 0.28; g/WD = 0.38; g/W1 = 1.07; h/f = 0.20; h/L1 = 0.06; WD/LD = 0.92.

OCCURRENCE.—Upper Dhruma Formation (Zone not placed): S1469.

SPECIMEN EXAMINED.— USNM 380475.

Habrobrochus Cooper, 1983

Habrobrochus amygdaloideus, new species

PLATE 31: FIGURES 13–21

DIAGNOSIS.—Longitudinally subelliptical, moderately folded *Hadrobrochus*.

DESCRIPTION.—Large, longitudinally subellitical, maximum width at anterior; ventral valve deeper than dorsal valve. Anterior margin narrowly rounded; anterolateral extremities rounded; posterolatral margins gently convex forming acute angle. Anterior commissure narrowly, sulciplicate. Beak, short, narrow, suberect, slightly labiate; symphytium partially visible. Foramen large, permesothyridid to mesothyridid. Smooth.

Ventral valve gently convex in side view, broadly gently convex in anterior profile with rounded slopes. Umbonal region swollen, swelling expanding to median region, flattening at anterior to form shallow sulcus at anterior, sulcus occupied by low, short elevation. Tongue short, bilobed.

Dorsal valve flatly convex in side view, moderately domed with steeply sloping sides in anterior profile. Umbonal and median regions swollen, swelling continued anteriorly to form low fold in anterior third. Sulcus in fold, shallow, often indistinct.

Interior: Ventral valve not seen. Dorsal valve with small semielliptical cardinal process, slightly bilobed. Loop occupying half valve length, $^1/_3$ to $^1/_4$ valve width. Socket ridges thin, curved bounding narrow sockets. Outer hinge plates narrow, concave, short, dorsally attached to crural base. Crural processes anterior of midloop, drawn into needle-like points. Descending lamellae moderately long, slightly bowed laterally. Transverse band forming narrow arch with flattened, protuberant crest.

LOOP STATISTICS.—USNM 380474d: angle = 34°; W1/L1 = 0.55; L1/LD = 0.45; W1/WD = 0.27; a/L1 = 0.55; b/L1 = 0.45; c/L1 = 0.30; d/L1 = 0.25; e/L1 = 0.20; f/L1 = 0.25; g/WD = 0.29; g/W1 = 1.18; h/f = 0.40; h/L1 = 0.10; WD/LD = 0.91.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380474a	29.0	25.0	22.0	14.8	78
380474b	30.8	26.5	22.0	16.0	73
380474c	22.3	19.4	20.0	10.0	72
380474d	?	23.7	20.0	?	?
380630	28.2	23.6	21.0	14.2	69
380631	26.8	21.8	19.3	13.2	75

OCCURRENCE.—Tuwaiq Mountain Formation: S1467. Hanifa Formation: S1443, KK10-26.5.

TYPES.—Holotype: USNM 380474a. Paratypes: USNM 380474b–e, 380512a,b, 380630, 380631.

DISCUSSION.—This species resembles the *Bihenithyris weiri* (Cooper, 1983:87, pl. 31: figs. 17–23, not *B. weiri* Muir-Wood, 1935) from Israel in its amygdaloidal form and gently sulciplicate folding. It differs, however, in its larger size and more slender proportions. The loop dimensions are very close.

The loop dimensions of this Saudi Arabian species are very close to those of "*Terebratula*" *subsella* Leymerie as figured by Cooper and now referred to *Habrobrochus* Cooper (1983:87). These have less strong folding than that of typical *Bihenithyris* and the other species of *Bihenithyris* described herein.

Loboidothyris Buckman, 1917

Loboidothyris? species

PLATE 26: FIGURES 19–21

DESCRIPTION.—Large, longitudinally ovate, maximum width anterior of midvalve. Ventral valve deeper than dorsal valve. Anterior narrowly rounded, sides broadly rounded; apical angle acute. Lateral commissure gently sigmoidal; anterior commis-

sure sulciplicate. Beak short, pressed onto dorsal umbo. Foramen large, permesothyridid. Smooth.

Ventral valve strongly convex in side view; anterior view forming high dome with steeply sloping sides. Umbonal and median regions swollen. Sulcus shallow, bounded by 2 narrowly rounded costae; sulcus occupied by a fairly wide low costa extending about 1/3 valve length toward posterior. Tongue short bilobed.

Dorsal valve gently convex in posterior half, flattened anteriorly in side view; anterior view forming low dome with short moderately steep sides. Median region gently swollen. fold short, bounding costae broadly rounded, extending posteriorly about 1/4 valve length.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380472: length 36.2, dorsal valve length 29.0, width 28.3, thickness 23.0, apical angle 75°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1167.

SPECIMEN EXAMINED.— USNM 380472.

DISCUSSION.—This species is smaller than *Loboidothyris perovalis* (J. de C. Sowerby, 1825), differing in a slightly more convex dorsal valve and somewhat stronger anterior folding. The ventral valve is more convex than that of the English species and the beak more convex and incurved. *Loboidothyris* is a much misidentified genus having been described from rocks of Bajocian to Callovian age. In absence of interior detail assignment of this Saudi Arabian specimen is tentative.

Pionopleurum, new genus

TYPE SPECIES.—*Pionopleurum obesum*, new species.

DIAGNOSIS.—Large, roundly oval, subspherical; valves swollen. Beak rounded, short; sulciplicate; foramen large mesothyridid to permesothyridid. Smooth. Loop wider than long; crural processes anterior of midloop.

SPECIMENS STUDIED.—31.

GEOLOGICAL OCCURRENCE.—Bathonian (Zone?) to Callovian.

ETYMOLOGY.—Greek *pion* (fat, plump); *pleuron* (rib).

DISCUSSION.—The great width of the loop and the rotundity of this genus suggest *Sphaeroidothyris* Buckman, 1917. The loop proportions of the two genera are close but the loop angle and length of terminal points differ. The terminal points of *Pionopleurum* are longer than those of *Sphaeroidothyris*. The anterior folding of the Saudi Arabian genus is stronger than that usual in *Sphaeroidothyris* sensu lato. The type species of *Sphaeroidothyris* is rectimaginate to faintly uniplicate (Cooper, 1983, pl. 44: fig. 2).

Pionopleurum compactum, new species

PLATE 26: FIGURES 10–18

DIAGNOSIS.—Small *Pionopleurum*.

DESCRIPTION.—Small, roundly oval, maximum width anterior to midvalve; sides and anterior rounded; apical angle near 90°. Anterior commissure moderately sulciplicate. Beak short, erect; foramen large, permesothyridid. Smooth.

Ventral valve moderately convex in side view, most convex in umbonal region; anterior profile forming moderately strong dome with steep sides. Umbonal and median regions swollen. Anterior with broad, shallow sulcus occupied by poorly formed costa.

Dorsal valve slightly less convex than ventral valve, in side view, somewhat more strongly domed than ventral valve in anterior profile. Umbonal and median regions swollen. Anterior with narrow fold with short median groove.

Interior: Ventral valve not seen. Dorsal valve with wide loop occupying 2/5 valve length, 1/3 valve width. Socket ridges thin, inner hinge plates narrow, concave, dorsally attached. Crural processes anterior of midloop. Lateral lamellae sort; transverse band wide, protuberant.

LOOP STATISTICS.—USNM 380484e (imperfect loop): angle = 41°; W1/L1 = 0.82; L1/LD = 0.44; W1/WD = 0.34; a/L1 = 0.59; b/L1 = 0.41; c/L1 = 0.30; d/L1 = 0.29; e/L1 = 0.11; f/L1 = 0.30; g/WD = 0.32; g/W1 = 0.92; h/f = ?; h/L1 = ?; WD/LD = 0.95.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380408	24.0	19.6	19.6	16.5	87
380484a	20.6	17.8	19.2	15.3	92
380484b	22.2	18.2	18.2	15.5	84

OCCURRENCE.—Dhruma Formation (Zone not placed): S1447.

TYPES.—Holotype: USNM 380408. Paratypes: USNM 380484a–e.

DISCUSSION.—The loops of *P. compactum* and *P. obesum*, new species, are in close accordance. The two species, however, are quite unlike, the former being much smaller, less swollen, and with less strong anterior folding.

Pionopleurum obesum, new species

PLATE 27: FIGURES 22–36

DIAGNOSIS.—Large inflated *Pionopleurum* with sulciplicate anterior commissure.

DESCRIPTION.—Large rotund, both valves inflated. Ventral valve deeper than dorsal valve. Sides rounded, maximum width slightly anterior to midvalve; apical angle variable. Anterior commissure sulciplicate. Beak short, erect, hiding symphytium; foramen fairly large permesothyridid. Surface smooth except for incremental lines of growth.

Ventral valve strongly convex in side view, strongly domed

with steep sides in anterior profile. Umbonal and median regions inflated. Sulcus originating at anterior third, wide, shallow, occupied by broad costa. Tongue short, bilobed.

Dorsal valve strongly convex in side view, strongly domed with precipitous sides in anterior view, doming greater than that of ventral valve. Fold restricted to anterior third, formed by 2 short costae separated by narrow groove.

Interior: Ventral valve not seen. Dorsal valve with small semielliptical cardinal process. Socket plates curved, thin, erect, bounding narrow sockets. Fulcral plates thin, laterally extended. Outer hinge plates narrow, deeply concave, short with long taper, attached dorsally. Crura short. Crural processes broad at base tapering ventrally to sharp point. Descending lamellae short, flaring; transverse band forming broad arch with moderately steep sloping sides; crest flattened occupying 1/4 loop width.

LOOP STATISTICS.—USNM 38481c: angle = 41°; W1/L1 = 0.92; L1/LD = 0.46; W1/WD = 0.41; a/L1 = 0.54; b/L1 = 0.46; c/L1 = 0.25; d/L1 = 0.29; e/L1 = 0.15; f/L1 = 0.31; g/WD = 0.26; g/W1 = 0.42; h/f = 0.44; h/L1 = 0.13; WD/LD = 1.07.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380290	35.2	29.5	29.4	28.0	80
380481a	32.0	28.0	27.6	19.7	85
380482	30.2	26.3	26.7	21.4	90
380483a	26.3	23.4	25.0	18.0	107
380627	30.0	26.0	25.5	20.7	87

OCCURRENCE.—Dhruma Formation (Zone not placed): S1156, S1447, S1449, S1456, S1457. Tuwaiq Mountain Formation: S1446.

TYPES.—Holotype: USNM 380290. Paratypes: USNM 380481a–c, 380482, 380483a,b, 380627.

DISCUSSION.—This species differs from *P. compactum*, new species, in its larger size and stronger folding. It is much more strongly folded than species of *Sphaeroidothyris* Buckman, 1917, the type of which is rectimarginate or very slightly uniplicate. The definition of *Sphaeroidothyris* includes anteriorly folded forms, but the folding is usually restricted to the anterior margin and is not shared by the anterior part of the shell as in *Pionopleurum*. Furthermore, it has been shown that forms identified as *Sphaeroidothyris* have loops far different from that of the type species, *S. globisphaeroidalis* Buckman, 1917 (Cooper, 1983:147–149).

Plectothyris Buckman, 1917

Plectothyris? species

PLATE 25: FIGURES 5–7

DESCRIPTION.—Medium, roundly oval, length greater than width, maximum width near midvalve. Anterior narrowly rounded, sides strongly rounded; apical angle acute. Anterior commissure rectimarginate. Beak fairly long, narrow, erect. Foramen moderately large, mesothyridid. Symphytium partially visible. Most of surface smooth, periphery costate.

Ventral valve gently convex in side view, broadly domed with steeply sloping sides in anterior profile. Umbonal and median regions narrowly swollen, swelling continued to anterior margin.

Dorsal valve flatly convex in side view, moderately domed in anterior view. Median region moderately swollen, swelling continued to anterior margin, meeting ventral median swelling to make narrow anterior protuberance.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380373: length 22.4, dorsal valve length 19.5, width 18.3, thickness 11.6, apical angle 75°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1485.

SPECIMEN EXAMINED.—USNM 380373.

DISCUSSION.—In absence of knowledge of its interior details this specimen has been placed in *Plectothyris* because of its rectimarginate anterior commissure and costate periphery. This is a smaller species than *P. fimbria* (J. Sowerby, 1822) of the British Bajocian.

Pleuraloma, new genus

TYPE SPECIES.—*Pleuraloma labiatum*, new species.

DIAGNOSIS.—Medium to large, elongate oval to roundly oval terebratulaceans with rectimarginate anterior commissure; lateral margins costate, body of shell smooth. Loop occupying half length, 1/3 width of dorsal valve. Crural processes anterior of midloop.

SPECIMENS STUDIED.—24.

OCCURRENCE.—Callovian.

ETYMOLOGY.—Greek, *pleuron* (rib), plus *loma* (fringe).

DISCUSSION.—This genus is represented by several closely related species as though these brachiopods were experimenting with costation. This genus is similar to *Arapsopleurum*, new genus, in appearance; the latter, however, is sulciplicate. It differs from *Dissoria*, new genus, which has superimposed costae in its uniplicate commissure.

Pleuraloma abruptum, new species

PLATE 27: FIGURES 19–21

DIAGNOSIS.—Small *Pleuraloma* with strong costation on anterior third to half of ventral valve.

DESCRIPTION.—Small, oval, inequivalve, ventral valve deeper than dorsal valve. Anterior narrowly rounded, sides broadly rounded; apical angle acute. Anterior commissure rectimarginate. Beak low, suberect, obliquely truncated, labiate. Foramen large, permesothyridid; symphytium concealed. Peripherally costate, costae on dorsal valve marginal,

those on ventral valve occupying anterior third.

Ventral valve strongly convex in lateral view, strongly domed with precipitous sides in anterior profile. Median region strongly swollen. Sulcus indistinct, marked by costae. No tongue.

Dorsal valve flatly convex in side view, flatly domed with short precipitous sides in anterior profile. Fold scarcely visible.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380269: length 21.0, dorsal valve length 17.0, width 17.0, thickness 14.3, apical angle 73°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPE.—Holotype: USNM 380269.

DISCUSSION.—This is a small *Pleuroloma*. It is distinguished from *P. convexum*, new species in having a less plump dorsal valve and in having stronger costae. This species is larger, with finer costae than *P. anomalum*, new species.

Pleuraloma anomalum, new species

PLATE 25: FIGURES 12–15

DIAGNOSIS.—Small, *Pleuraloma* with anteriorly geniculate dorsal valve.

DESCRIPTION.—Small, imperfect, lozenge-shaped with maximum width at about midvalve. Anterior margin narrowly rounded, sides nearly parallel; apical angle not measurable. Anterior commissure uniplicate. Beak damaged. Surface in posterior third, smooth, anterior third marked by distant, angular costate.

Ventral valve strongly convex, forming narrowly convex high dome in anterior view. Anterior $^2/_3$ marked by single strong angular median costa flanked by 4 to 6 lesser angular costae on the sides.

Dorsal valve gently convex in side view with anterior $^1/_3$, costate part geniculated. Anterior view forming narrow high dome. Costate part with two strong median costae forming fold, flanked by about 5 lesser costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380353: length 18.7, dorsal valve length 14.3, width 13.3, thickness 14.8, apical angle ? (not measurable).

OCCURRENCE.—Tuwaiq Mountain Formation: S296.

TYPE.—Holotype: USNM 380353.

DISCUSSION.—This species is unique because of its small size and the abrupt geniculation of the dorsal valve. Its costation is also distinctive with its prominent angular median costa on the ventral valve. The geniculation and costation distinquish this species from all other species of *Pleuraloma*.

Pleuraloma? circulare, new species

PLATE 25: FIGURES 16–18

DIAGNOSIS.—Large subcircular *Pleuraloma?*.

DESCRIPTION.—Large, roundly oval, longer than wide, maximum width at about midvalve. Ventral valve more convex than dorsal valve. Sides and anterior rounded, apical angle acute. Anterior commissure rectimarginate. Beak short, erect, damaged. Foramen large, permesothyridid(?). Surface, except for periphery smooth; peripherally costate, costae confined to margins.

Ventral valve moderately convex in lateral view, forming broad dome with long sloping sides in anterior profile. Median region swollen. No clearly marked sulcus, anterior slightly narrowly protuberant.

Dorsal valve flatly convex in side view, forming broad low dome with gently sloping sides in anterior profile. Slight suggestion of low narrow fold at middle of anterior, meeting narrow sulcation of ventral valve, junction not affecting rectimarginate condition.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380468: length 31.7, dorsal valve length 27.3; width 27.5, thickness 17.7, apical angle 83°.

OCCURRENCE.—Tuwaiq Mountain Formation: S293.

TYPE.—Holotype: USNM 380468.

DISCUSSION.—Because of its strong external resemblance to the Bajocian genus *Plectothyris*, this species is unlike any other *Pleuraloma*. In absence of its interior details and in view of its Upper Jurassic position it seems best to place it with *Pleuraloma*. It is quite different from any other specimens herein referred to *Pleuraloma*.

Pleuraloma convexum, new species

PLATE 27: FIGURES 16–18; PLATE 31: FIGURES 4–6

DIAGNOSIS.—Large *Pleuraloma* with both valves strongly convex, peripheral costation very fine.

DESCRIPTION.—Large, roundly oval, longer than wide, maximum width at about midvalve. Ventral valve deeper than dorsal valve. Anterior subtruncate sides gently rounded; apical angle acute. Anterior commissure rectimarginate. Beak narrow, suberect; foramen large, permesothyridid. Costation marginal, costae fine; remainder of valves smooth.

Ventral valve fairly strongly convex in lateral view; strongly domed with steeply sloping sides in anterior profile. Median region strongly swollen. Sulcus, wide, shallow, barely perceptible in anterior quarter. No tongue.

Dorsal valve fairly strongly convex in side view, strongly domed with steeply sloping sides in anterior profile, doming stronger than that of ventral valve. Median region inflated. No fold developed.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380406: length 24.0, dorsal valve length 19.8, width 20.0, thickness 18.0, apical angle 74°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380406. Paratype: USNM 380467.

DISCUSSION.—This species is like *P. robustum*, new species,

in the fine costation of the margins; it is however, plumper, less wide, and with nonlabiate beak. The finely costate margins distinguish it from all other species described herein.

Pleuraloma labiatum, new species

PLATE 28: FIGURES 1–9

DIAGNOSIS.—Strongly biconvex *Pleuraloma* with strong anterior costae.

DESCRIPTION.—Large, elongate oval, ventral valve deeper than dorsal valve; anterior margin rounded, sides broadly rounded, apical angle acute. Anterior commissure rectimarginate. Beak fairly long, narrow, suberect, truncated obliquely, strongly labiate. Foramen large, permesothyridid; symphytium hidden. Surface smooth except for peripheral third which is costate; costae narrowly rounded.

Ventral valve strongly convex in side view, strongly domed with precipitous sides in anterior profile. Valve strongly swollen; sulcus not formed, in its place low elevation with costae.

Dorsal valve gently convex in side view, strongly domed with precipitous sides in anterior profile, doming greater than that of ventral valve. Valve strongly, somewhat narrowly swollen medially; forming indistinct fold meeting anterior swelling of ventral valve.

Interior: Ventral valve not seen. Dorsal valve with small, narrowly semielliptical cardinal process. Loop long, narrow, about 1/2 valve length, 1/3 valve width. Socket ridges thin; outer hinge plates narrow, concave, attached on dorsal edge of crural bases. Cardinal process short, sharply pointed, anterior to midvalve. Lateral lamellae bowed laterally. Transverse band thick where attached to descending lamellae, thinning to narrow, protuberant crest. Terminal points long.

LOOP STATISTICS.—USNM 380465b: angle = 25°; W1/L1 = 0.46; L1/LD = 0.52; W1/WD = 0.31; a/L1 = 0.54; b/L1 = 0.46; c/L1 = 0.29; d/L1 = 0.25; e/L1 = 0.13; f/L1 = 0.33; g/WD = 0.37; g/W1 = 1.55; h/f = 0.13; h/L1 = 0.04; WD/LD = 0.78.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380402	24.4	20.5	17.7	16.0	61
380465a	25.0	20.5	18.2	17.6	56

OCCURRENCE.—Tuwaiq Mountain Formation: S296, S1702.

TYPES.—Holotype: USNM 380465a. Paratypes: USNM 380402, 380465b.

DISCUSSION.—This species is characterized by its elongate oval outline, thus differing from *P. circulare*, new species, *P. triangulatum*, new species, and *P. robustum*, new species. *Pleuraloma convexum*, new species, is rounder with more subdued peripheral costation.

Pleuraloma multicostatum, new species

PLATE 25: FIGURES 19–21

DIAGNOSIS.—Medium *Pleuraloma* with few strong anterior costae, lateral costae fine, occupying the flanks.

DESCRIPTION.—Medium, elongate oval, maximum width anterior of midvalve. Anterior truncate, sides gently rounded, apical angle acute. Anterior commissure rectimarginate. Beak low, erect; foramen large permesothyridid. Posterior two-thirds smooth, anterior strongly costate sides with fine costae.

Ventral valve moderately convex in side view, strongly, roundly domed with steep sides in anterior profile. Median region strongly swollen; anterior third with 2 strong costae slightly elevated.

Dorsal valve gently convex in side view, strongly, roundly domed in anterior view, doming about equal to that of ventral valve. Median region swollen. Anterior margin with 3 short costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380407: length 24.0, dorsal valve length 19.6, width 18.0, thickness 16.7, apical angle 62°.

OCCURRENCE.—Tuwaiq Mountain Formation: 1702.

TYPE.—Holotype: USNM 380407.

DISCUSSION.—This species resembles *P. varicostatum*, new species, in having varied costation. It differs in being smaller, differently proportioned and in having stronger costation.

Pleuraloma robustum, new species

PLATE 27: FIGURES 10–12

DIAGNOSIS.—Large roundly oval *Pleuraloma* with acute apical angle.

DESCRIPTION.—Large, roundly oval, longer than wide, maximum width at about midvalve. Anterior and sides rounded, apical angle acute. Anterior commissure rectimarginate. Beak low, narrow, suberect, obliquely truncated, strongly labiate. Foramen small, permesothyridid. Symphytium hidden. Surface smooth except for margins which are finely costate.

Ventral valve moderately convex in side view, most convex umbonally. Broadly domed with sloping sides in anterior profile. Median and umbonal regions swollen; anterior gently convex, no sulcus formed.

Dorsal valve gently convex in side view, broadly domed in anterior view with steeply sloping sides, doming greater than that of ventral valve. Strongly swollen medially; no fold developed.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380470: length 26.7,

dorsal valve length 22.7, width 22.0, thickness 16.8, apical angle 74°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1715.

TYPE.—Holotype: USNM 380470.

DISCUSSION.—See *P. convexum*, new species, for comparison.

Pleuraloma subaequicostatum, new species

PLATE 25: FIGURES 22–24

DIAGNOSIS.—Small *Pleuraloma* with peripheral costae of nearly same strength.

DESCRIPTION.—Small, elongate oval, maximum width slightly anterior of midvalve. Anterior narrowly rounded, sides gently rounded, apical angle acute. Anterior commissure rectimarginate. Beak low, slightly labiate, suberect, obliquely truncated. Foramen small, permesothyridid. Symphytium partially visible. Periphery fairly strongly costate.

Ventral valve gently convex in side view with umbo strongly curved. Anterior profile forming low dome. Median region swollen. Sulcus shallow, occupied by 3 costae.

Dorsal valve flatly convex in side view, broadly, more strongly domed than ventral valve in anterior profile. Median region swollen. Fold consisting of 4 short costae meeting folded part of ventral valve.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380409: length 21.0, dorsal valve length 18.0, width 15.6, thickness 12.6, apical angle 72°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1702.

TYPE.—Holotype: USNM 380409.

DISCUSSION.—This species differs from *P. abruptum*, new species, in its stronger, more irregular costation and its narrow form. It differs from *P. multicostatum*, new species, in its smaller size and stronger, less varied costation.

Pleuraloma triangulatum, new species

PLATE 27: FIGURES 13–15

DIAGNOSIS.—Large widely triangular *Pleuraloma* with flattened margins.

DESCRIPTION.—Large, triangular maximum width in anterior third. Anterior margin broadly rounded, anterolateral extremities narrowly rounded, apical angle acute. Anterior commissure rectimarginate. Beak damaged. Surface smooth; margins costate, flattened.

Ventral valve fairly strongly convex in side view, forming high steep-sided dome in anterior profile. Strongly inflated medially. Margins abruptly geniculated.

Dorsal valve flatly convex in side view, gently, broadly domed in anterior view. Median region gently swollen; anterior strongly geniculated to form flattened margin with geniculated part of ventral valve.

MEASUREMENTS (in mm).—USNM 380403: length 28.7? [damaged], dorsal valve length 23.5, width 26.4, thickness 19.3, apical angle 65°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1702.

TYPE.—Holotype: USNM 380403.

DISCUSSION.—This species is larger, more triangular and differently proportioned than *P. robustum*, new species. The anterior geniculation is unlike that of any other *Pleuroloma*. Similar examples of anterior geniculation have been recorded by Dagis (1968, pl. 11: figs. 1–4) in his Jurassic genus *Lenothyris*. Middlemiss (1959, pl. 18: figs. 5a-c) has illustrated specimens referred to *Sellithyris* from the Cretaceous of England. Neither genus is peripherally costate.

Pleuraloma varicostatum, new species

PLATE 28: FIGURES 13–16

DIAGNOSIS.—*Pleuraloma* with strong anterior costae, subdued marginal costae on sides.

DESCRIPTION.—About medium, narrowly elongate oval maximum width slightly anterior of midvalve; anterior margin narrowly rounded, sides gently rounded; apical angle acute. Anterior commissure rectimarginate. Beak narrowly rounded, strongly labiate; foramen large, permesothyridid. Surface, except for periphery, smooth; lateral periphery serrate; anterior periphery costate.

Ventral valve moderately convex, most convex in umbonal region in side view. Anterior profile forming moderately rounded dome with precipitous sides. Umbonal and median regions swollen. Anterior third with 3 costae occupying middle.

Dorsal valve gently convex in side view; somewhat narrowly domed with steep sides in lateral profile. Doming narrower and stronger than that of ventral valve. Anterior with three costae in an incipiently sulcate depression.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380356: length 25.3, dorsal valve length 22.3, width 17.7, thickness 16.0, apical angle 58°.

OCCURRENCE.—Tuwaiq Mountain Formation: S1702.

TYPE.—Holotype: USNM 380356.

DISCUSSION.—This species is distinguished from other *Pleuraloma* by its costate anterior with lateral costation restricted to the margins. It differs from *P. labiatum*, new species, in the nature of costation and narrow shell. The anterior folding of this species is incipiently sulciplicate.

Pleuraloma species

PLATE 27: FIGURES 1–6

DESCRIPTION.—A small narrowly ovate species with badly damaged beak indicates another species of *Pleuraloma* unlike those described above. It is finely costate on the periphery with the costae of the ventral valve extending posteriorly for about 1/4 valve length.

Another imperfect specimen with good dorsal valve yielded a loop on excavation, which is not perfect especially as regards the terminal points. The cardinal process in a small semielliptical shelf. The socket ridges are thin; the outer hinge plates short, concave, and dorsally attached. The crural processes are needle sharp and located anterior of midloop. The lateral lamellae are short, slightly bowed laterally. The transverse band, like the terminal points, is incomplete.

LOOP STATISTICS.—USNM 380525a (part of loop unclear): angle = 30°; W1/L1 = 0.55; L1/LD = 0.49; W1/WD = 0.31; a/L1 = 0.61; b/L1 = 0.39; c/L1 = 0.28; d/L1 = 0.33; e/L1 = 0.17; f/L1 = 0.22?; g/WD = 0.31; g/W1 = 1.30; h/f = 0.50?; h/L1 = 0.10?; WD/LD = 0.87.

OCCURRENCE.—Tuwaiq Mountain: S1715.

SPECIMENS EXAMINED.—USNM 380525a,b.

Pseudowattonithyris Almeras, 1971

Pseudowattonithyris? species

PLATE 25: FIGURES 25–27

Medium, narrowly elongate oval, ventral valve deeper than dorsal valve; maximum width at midvalve. Anterior narrowly rounded, sides gently rounded, subparallel; apical angle acute. Anterior commissure narrowly sulciplicate. Beak low, suberect, pressed onto umbo to conceal symphytium. Foramen moderately large, mesothyridid. Smooth, with fine incremental lines of growth.

Ventral valve strongly convex in side view, strongly, roundly domed with long precipitous sides in anterior profile. Valve swollen from beak to anterior margin. Sulcus exhibited only at anterior, forming short bilobed tongue.

Dorsal valve gently convex in side view, forming smooth moderately rounded dome with precipitous sides in anterior profile. Valve swollen from posterior to anterior. Fold at anterior consisting of two very short costae with short shallow depression between.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380414: length 20.7, dorsal valve length 21.8, width 19.0, thickness 18.8, apical angle 70°.

OCCURRENCE.—Middle Dhruma Formation (*Dhrumaites* Zone): KK9-102.

SPECIMEN EXAMINED.—USNM 380414.

DISCUSSION.—A single imperfect specimen is placed here with a query. This is a plumper and less strongly biplicate species than those figured by Almeras (1971, pl. 74).

Somalithyris Muir-Wood, 1935

Somalithyris elliptica, new species

PLATE 28: FIGURES 20–22

DIAGNOSIS.—*Somalithyris* of medium size with narrowly elliptical outline.

DESCRIPTION.—Medium, elliptical or oval in outline, with maximum width at about midvalve. Anterior narrowly rounded, sides gently rounded, apical angle acute. Anterior commissure sulciplicate. Beak low, rounded, suberect, obliquely truncated, foramen large, permesothyridid; deltidial plates concealed. Smooth.

Ventral valve slightly deeper than dorsal valve, gently convex in side view, moderately domed with sloping sides in anterior profile. Median region swollen, swelling extending from umbo to anterior margin. Sulcus defined in anterior third, occupied by median swelling. Tongue moderately long, bilobed.

Dorsal valve gently convex with maximum convexity at midvalve in side view, more strongly domed and with steeper lateral slopes than ventral valve in anterior profile. Median region swollen. Fold originating in anterior quarter, low defined by short bounding costae enclosing short, fairly deep depression.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380538: length 26.1, dorsal valve length 22.5, width 21.0, thickness 16.1, apical angle 73°, fold width 13.0.

OCCURRENCE.—Hanifa Formation: KK10-25, -25.5.

TYPES.—Holotype: USNM 380538. Paratype: USNM 380541.

DISCUSSION.—This species is distinguished from *S. subcircularis*, new species, and *S. triangulata*, new species, by its smaller size and narrowly oval shape. It is more narrowly oval and smaller than *S. ovata*, new species, and it is larger and with more rounded sides than *S. parva*, new species.

Somalithyris ovata, new species

PLATE 28: FIGURES 23–42, PLATE 30: FIGURE 24

DIAGNOSIS.—Elongate oval *Somalithyris*.

DESCRIPTION.—Large, elongate oval, subequally convex; maximum width near midvalve. Sides broadly rounded, anterior margin more narrowly rounded; apical angle near a right angle. Anterior commissure more or less strongly sulciplicate. Beak low, rounded, suberect to erect. Foramen moderately large, permesothyridid. Surface with incremental lines of growth only.

Ventral valve fairly evenly, moderately convex in side view, moderately domed with sloping sides in anterior view. Valve medially swollen. Sulcus poorly defined, limited to anterior third; Median elevation in sulcus indistinct.

Dorsal valve gently convex in side view, moderately domed much like that of ventral valve in anterior profile. Median region swollen. Fold short, in anterior third with median depression poorly defined; costae bounding sulcus short, variable in strength.

Interior: Ventral valve with small pedicle collar. Other details indistinct. Dorsal valve with divergent linear adductor scars and small semielliptical shelf-like cardinal process. Loop $^2/_5$ valve length, $^1/_3$ valve width. Outer hinge plates short,

narrow, dorsally attached. Socket ridges thin. Crural processes long, thin, posterior of midloop; lateral lamellae short, widely bowed. Transverse band, narrow, strongly arched with narrow protuberant crest. Terminal points fairly long.

LOOP STATISTICS.—USNM 380523: angle = 36°; W1/L1 = 0.75; L1/LD = 0.39; W1/WD = 0.33; a/L1 = 0.37; b/L1 = 0.63; c/L1 = 0.28; d/L1 = 0.09; e/L1 = 0.25; f/L1 = 0.38; g/WD = 0.32; g/W1 = 1.00; h/f = 0.17; h/L1 = 0.06; WD/LD = 0.90.

USNM 380295: angle = 40°; W1/L1 = 0.79; L1/LD = 0.46; W1/WD = 0.35; a/L1 = 0.39; b/L1 = 0.61; c/L1 = 0.34; d/L1 = 0.05; e/L1 = 0.26; f/L1 = 0.35; g/WD = 0.35; g/W1 = 1.00; h/f = 0.11; h/L1 = 0.04; LD/WD = 1.05.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380203a	32.6	28.7	26.4	18.2	80
380203b	25.0	22.4	21.4	14.6	89
380236	25.0	21.8	21.4	14.2	88
380293a	29.4	25.7	23.8	16.4	85
380293b	29.0	25.6	24.5	16.0	88
380549	32.0	28.0	26.7	18.3	88

OCCURRENCE.—Hanifa Formation: S625, S1298, KK10-25, -25.5, -26, -35, -37, -37.5.

TYPES.—Holotype; USNM 380203a. Paratypes: USNM 380203b, 380236, 380293a,b, 380295, 380416, 380523, 380533, 380535, 380541, 380549, 380550a,b.

DISCUSSION.—This species differs from *Somalithyris subcircularis*, new species, in its oval outline, somewhat thinner shells, and generally more subdued sulciplication. It differs from *S. triangulata*, new species, in its outline and lesser degree of anterior plication. It differs from *S. macfadyeni* Muir-Wood (1935) in smaller size, ovate form, and lesser degree of folding.

Somalithyris parva, new species

PLATE 29: FIGURES 1–4

DIAGNOSIS.—Small, narrowly oval *Somalithyris*.

DESCRIPTION.—Small, elongate oval, maximum width anterior of midvalve. Valves nearly equal in depth, ventral valve slightly deeper than dorsal valve. Anterior narrowly rounded, sides gently rounded. Apical angle acute. Anterior commissure narrowly sulciplicate. Beak narrow, low; foramen small, permesothyridid. Smooth.

Ventral valve moderately convex in side view, narrowly domed with steeply sloping sides. Median region swollen. Sulcus in anterior third, shallow; tongue short bilobed.

Dorsal valve gently convex in side view, fairly strongly domed with steep sides in anterior view, doming slightly greater than that of ventral valve. Median region swollen. Fold narrow confined to anterior.

Interior: Ventral valve with short excavate pedicle collar. Dorsal valve with loop about 1/3 valve length, about 1/4 valve width. Outer hinge plates short, concave; crura short; crural processes broad at base, sharply pointed, anterior to midloop. Descending lamellae short, bowed laterally; transverse band strongly arched with broad base, narrowing crest.

LOOP STATISTICS.—Because the loop is seen from the posterior side, and in lateral view it is impossible to prepare reliable statistics.

MEASUREMENTS (in mm).—USNM 380527a: length 21.7, dorsal valve length 18.8, width 17.0, thickness 13.8, apical angle 87°, fold width 12.0.

OCCURRENCE.—Hanifa Formation: KK10-25; -25.5

TYPES.—Holotype: USNM 380527a. Paratypes: USNM 380524, 380527b–f.

DISCUSSION.—This species is the smallest of the somalithyrids and is distinguished from the new species *S. ovata* and *S. elliptica* by its narrow form, and less narrowed posterior.

Somalithyris rotundata, new species

PLATE 29: FIGURES 5–7

DIAGNOSIS.—Large nearly circular *Somalithyris* with strong sulciplication.

DESCRIPTION.—Large, subcircular, maximum width at midvalve. Sides and anterior margin rounded, apical angle obtuse. Strongly sulciplicate. Beak low, narrow, erect. Foramen small, permesothyridid. Symphytium concealed. Smooth.

Ventral valve moderately convex in side view, broadly domed with sloping sides in anterior view. Median region moderately swollen. Sulcus originating anterior of midvalve, shallow with broad median swelling extending posteriorly nearly to midvalve. Tongue fairly long, bilobed.

Dorsal valve gently convex, most convex at midvalve in side view; anterior view forming broad moderately high dome with long sloping sides. Fold narrow, anterior to midvalve consisting of two sharp costae separated by narrow, deep depression.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380284: length 28.4, dorsal valve length 24.0, width 28.1, thickness 16.0? (one damaged valve), apical angle 112°, fold width 15.8.

OCCURRENCE.—Hanifa Formation: S776.

TYPE.—Holotype: USNM 380284.

DISCUSSION.—This species differs from *S. subcircularis*, new species, in its more rounded form and much stronger anterior folding.

Somalithyris subcircularis, new species

PLATE 29: FIGURES 8–14

DIAGNOSIS.—Roundly oval *Somalithyris*.

DESCRIPTION.—Large, subcircular to roundly suboval, subequivalve, dorsal valve slightly less convex than ventral

valve. Sides and anterior rounded, apical angle obtuse. Anterior commissure rectimarginate in young perceptibly sulciplicate in adult. Beak short, erect, narrow; foramen fairly large, mesothyridid to permesothyridid. Smooth.

Ventral valve moderately convex in side view, most so in umbonal region; broadly domed with moderately sloping sides in anterior profile. Valve swollen in umbonal and median regions, flattened at anterior. Sulcus poorly developed, occupying anterior third, median fold incipient to poorly defined, short. Tongue short, faintly bilobed.

Dorsal valve gently to moderately convex in lateral view, broadly domed with short lateral slopes in anterior view. Valve swollen medially. Fold indistinct, wide, bounding costae low or incipient.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380222	34.3	29.3	30.6	19.7	97
380551a	24.3	21.3	24.0	12.8	99
380551b	24.2	21.5	22.3	13.7	103
380551c	21.3	18.4	20.4	11.0	96
380551d	19.0	16.5	17.8	9.6	97
380551e	13.4	12.2	12.5	7.3	96
380628	23.0	20.0	21.3	13.3	97

OCCURRENCE.—Hanifa Formation: S1053, KK10-25, -25.5, -26.

TYPES.—Holotype: USNM 380222. Paratypes: USNM 380528, 380529, 380551a-e, 380628.

DISCUSSION.—This species differs from *S. macfadyeni* Muir-Wood (1935) in its rounded outline and lesser development of anterior plication. It is differently shaped than *S. triangulata* and *S. ovata*, both new species.

Somalithyris triangulata, new species

PLATE 29: FIGURES 15–19

DIAGNOSIS.—Triangular *Somalirhynchia*.

DESCRIPTION.—Large subtriangular ventral valve deeper than dorsal valve. Maximum width at anterior. Anterior margin subnasute; anterolateral extremities narrowly rounded; apical angle acute. Beak, low, erect, labiate; foramen large permesothyridid. Anterior commissure broadly sulciplicate. Smooth.

Ventral valve gently convex in lateral view, with umbonal region strongly convex. Anterior profile forming broad low dome with long moderately sloping sides. Umbonal and median regions swollen. Sulcus broad, shallow, confined to anterior third, forming long tongue with median costa and bilobed extremity.

Dorsal valve flatly convex in side view, forming low, broad dome with long sloping sides in anterior profile. Umbonal and median regions swollen. Fold originating anterior of midvalve, low with gentle median depression.

Interior: Ventral valve with short excavate pedicle collar. Dorsal valve with short divergent adductor scars expanded anteriorly. Cardinal process small, semielliptical, shelf-like. Socket ridges, thin, outer hinge plates, concave narrow, dorsally attached.

MEASUREMENTS (in mm).—USNM 380420: length 34.0, dorsal valve length 29.0, width 28.3, thickness 18.6, apical angle 67°.

OCCURRENCE.—Hanifa Formation: S1443, KK10-25.5.

TYPES.—Holotype: USNM 380420. Paratype: USNM 380419.

DISCUSSION.—Its narrow triangular form differentiates this species from those described herein and Muir-Wood's (1935) species *S. macfadyeni* and *S. bihendulensis*.

Sphaeroidothyris Buckman, 1917

Sphaeroidothyris arabica, new species

PLATE 29: FIGURES 26–34

DIAGNOSIS.—*Sphaeroidothyris* with moderately swollen valves; rectimarginate anterior commissure.

DESCRIPTION.—Medium, subcircular, maximum width at midvalve. Ventral valve deeper than dorsal valve. Sides and anterior strongly rounded. Apical angle obtuse. Anterior commissure rectimarginate. Beak low, small, erect; foramen small, hypothyridid. Smooth.

Ventral valve moderately convex in side view, broadly, moderately domed with sloping sides in anterior profile. Umbonal and median regions swollen.

Dorsal valve moderately convex in lateral view, more strongly domed than ventral valve with steeper lateral slopes in anterior profile. Median region strongly swollen, swelling extending to all parts of valve.

Interior: Ventral valve not seen. Dorsal valve with wide loop. Cardinal process small, semielliptical shelf. Socket ridges thin; sockets narrow. Outer hinge plates short, concave, dorsally attached; crural processes anterior of midloop, long, needle sharp. Descending lamellae bowed laterally, short. Transverse band wide with thick base, narrowed, somewhat protuberant crest.

LOOP STATISTICS.—USNM 380486b (margins of dorsal valve incomplete): angle = 43°; W1/L1 = 0.84; L1/LD = ?; W1/WD = 0.34; a/L1 = 0.58; b/L1 = 0.42; c/L1 = 0.31; d/L1 = 0.27; e/L1 = 0.16; f/L1 = 0.26; g/WD = 0.36; g/W1 = 1.06; h/f = 0.30; h/L1 = 0.08; WD/LD = ?

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle
380411	21.0	18.7	20.3	14.8	106
380486a	20.0	18.0	20.7	13.3	110

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1056, S1166; (*Thambites* Zone): S1001, S1044.

TYPES.—Holotype: USNM 380486a. Paratypes: USNM 380411, 380486b.

DISCUSSION.—This species is smaller and less plump than *S. sphaeroidalis* (Auct.), which is strongly bioconvex and has a sulciplicate anterior commissure unlike that of *S. arabica*, which is rectimarginate.

Sphaeroidothyris sphaeroidalis (Auct.)

PLATE 29: FIGURES 35–39

DESCRIPTION.—Medium, globular, valves longer than wide, about equal in depth. Sides and anterior strongly rounded; apical angle obtuse. Maximum width near midvalve. Anterior commissure sulciplicate, the plication restricted to valve margin, not affecting body of shell. Beak low suberect, rounded, almost in contact with dorsal umbo. Foramen fairly large. Smooth.

Ventral valve fairly strongly convex in side view, strongly domed with precipitous sides in anterior view. All parts of valve swollen. Tongue very short, gently bilobed.

Dorsal valve strongly convex in side view, forming high dome in anterior view with precipitous sides; doming stronger than that of ventral valve.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380209: length 23.9, dorsal valve length 20.6, width 20.6, thickness 18.7, apical angle 93°.

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): KK8; (Zone not placed): S1687.

SPECIMEN EXAMINED.—USNM 380209.

DISCUSSION.—This species differs in size, greater convexity, and the wrinkling of the anterior commissure from *Sphaeroidothyris arabica*, new species. It is also in accordance with that large group of *Sphaeroidothyris* commonly identified as *S. sphaeroidalis* (J. de C. Sowerby, 1825). Specimens so referred vary in commissure characters from rectimarginate to uniplicate to sulciplicate, the degree of folding usually restricted to the margin. The type species is rectimarginate. Specimens figured by Davidson (1851–1852, pl. 11: figs. 9–18) are all nearly sphaerical and have a variety of anterior commissures. Sowerby's type (Davidson, 1851–1852, pl. 11: figs. 9, 9b,c) is illustrated as rectimarginate. The genus is greatly in need of revision. Cooper (1983:147) showed that specimens identified as *S. sphaeroidalis* may have very different loops.

Sphaeroidothyris species 1

PLATE 29: FIGURES 20–22

DESCRIPTION.—A small specimen unlike any of those above is rectimarginate with small erect beak and small hypothyridid foramen. Both valves are strongly swollen, the ventral valve slightly more so than the dorsal valve. The ventral valve is most convex in the umbonal region. Maximum width is a midvalve with the sides tapering anteriorly to produce narrowed anterior. The anterior commissure is rectimarginate.

MEASUREMENTS (in mm).—USNM 380386: length 17.7, dorsal bivalve length 15.6; width 16.3, thickness 13.2; apical angle angle 100°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1166, S1167.

SPECIMEN EXAMINED.—USNM 380386.

Sphaeroidothyris species 2

PLATE 30: FIGURES 5–7

DESCRIPTION.—A second specimen smaller that the preceding, yet an adult, has length and width nearly equal. It has very swollen valves of which the ventral valve is the deeper and more swollen of the two. The beak is small, erect with fairly large hypothyridid(?) foramen. The anterior commissure is rectimarginate.

MEASUREMENTS (in mm).—USNM 380497: length 14.6, dorsal valve length 12.3; width 14.5, thickness 11.9, apical angle 102°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1618.

SPECIMEN EXAMINED.— USNM 380497.

Stenorina, new genus

TYPE SPECIES.—*Stenorina parallela*, new species.

DIAGNOSIS.—Large, narrowly elongate, sides nearly parallel, ventral valve more convex than dorsal valve. Narrowly suliplicate. Beak narrow, long, erect; foramen large, mesothyridid. Smooth.

Interior: Ventral valve with pedicle collar. Dorsal valve with ventrally concave hinge plates; loop fairly long, narrow longer than wide (W1/L1 = 0.62), crural processes posterior of midloop. Transverse band steeply and narrowly arched. Terminal points long.

SPECIMENS STUDIED.—4.

GEOLOGICAL OCCURRENCE.—Callovian.

ETYMOLOGY.—Greek *stenos* (narrow).

DISCUSSION.—This genus is unusual for its elongated, narrow form, narrow anterior folding, and shallow dorsal valve.

Dorsoplicathyris Almeras (1971) and *Arcelinithyris* Almeras (1971) are elongate, narrow terebratulids, but they do not have the subparallel sides and strong folding of *Stenorina*, and they have deeper, more convex dorsal valves.

Stenorina parallela, new species

FIGURE 37; PLATE 29: FIGURES 23–25

DIAGNOSIS.—Elongate *Stenorina* with strong sulciplication.

DESCRIPTION.—Large, narrowly elongate with nearly parallel sides; length nearly twice width; ventral valve much deeper than dorsal valve. Anterior nasute, apical angle acute. Anterior commissure narrowly, strongly sulciplicate. Beak fairly long, subcarinate, erect, concealing symphytium. Foramen large, mesothyridid. Smooth.

Ventral valve strongly convex in side view, forming narrow, rounded dome with long vertical sides in anterior profile. Valve swollen from beak to anterior. Sulcus shallow, defined in anterior third, occupied by median costa extending posteriorly

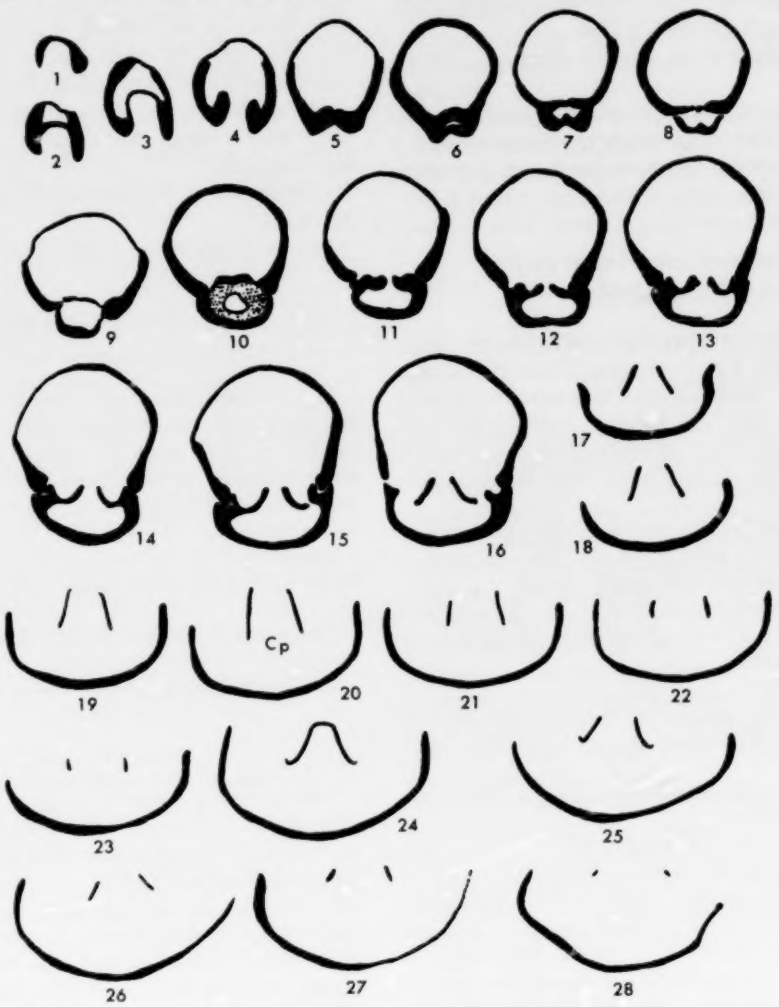

FIGURE 37.—*Stenorina parallela*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 1.0(1.0); 2, 0.3(1.3), 3, 0.3(1.6); 4, 0.5(2.1); 5, 1.0(3.1); 6, 0.3(3.4); 7, 0.5(3.9); 8, 0.3(4.2); 9, 0.6(4.8); 10, 0.3(5.1); 11, 0.5(5.6); 12, 0.3(5.9); 13, 0.5(6.4); 14, 0.3(6.7); 15, 0.6(7.3); 16, 0.3(7.6); 17, 0.6(8.2); 18, 0.3(8.5); 19, 0.5(9.0); 20, 0.6(9.6) (Cp = crural process); 21, 0.8(10.4); 22, 1.1(11.5); 23, 1.3(12.8); 24, 0.3(13.1); 25, 0.8(13.9); 26, 0.3(14.2); 27, 1.1(15.3); 28, 1.1(16.4). Loop ends at 16.4 mm, approximately ×2.5; length 35.7 mm; dorsal valve length 30.0 mm, width 20.5 mm; USNM 380647; Locality KK9-113-115.

almost to midvalve. Tongue long, bilobed. Dorsal valve flatly convex in side view, forming flat-topped, flat-sided dome in anterior profile. Fold defined by 2 strong, narrowly rounded costae extending posteriorly about 1/3 valve length; costae separated by deep groove extended anteriorly as short, sharp projection producing nasute anterior.

Interior: Loop fairly long, 0.4 valve length and 0.4 valve width; crural processes posterior to midloop; transverse band narrowly arched; terminal points long.

LOOP STATISTICS.—USNM 380647: angle = 34°; W1/L1 = 0.62; L1/WD = 0.44; W1/WD = 0.40; a/L1 = 0.38; b/L1 = 0.62; c/L1 = 0.23; d/L1 = 0.15; e/L1 = 0.13; f/L1 = 0.49; g/WD = 0.4; g/W1 = 1.0; h/f = ? (cannot measure); WD/LD = 0.67.

MEASUREMENTS (in mm).—USNM 380283: length 34.0, dorsal valve length 28.0, width 19.2, thickness 19.0, apical angle 64°.

USNM 380647: dorsal valve length = 30.0, width 20.5.

OCCURRENCE.—Upper Dhruma Formation (Upper Atash Member): KK9-112–114, -113–115.

TYPES.—Holotype: USNM 380283. Paratype: USNM 380647.

DISCUSSION.—The elongate form and almost parallel sides of this species are unique characters. The folding suggests *Heimia*? *incurvatum* Muir-Wood, 1935, which, although narrowly elongate has rounded sides and its anterior is not nasute.

Stiphrothyris Buckman, 1917

Stiphrothyris? species 1

PLATE 31: FIGURES 22–27

DESCRIPTION.—Large, elongate oval, valves swollen, ventral valve with greater depth than dorsal valve. Anterior narrowly rounded, sides rounded, apical angle about 90°. Anterior commissure narrowly sulciplicate. Beak short, subcarinate, erect; foramen fairly large, mesothyridid. Smooth.

Ventral valve fairly strongly convex in side view, with umbonal region strongly rounded; anterior profile forming high, narrowly rounded dome with steep sides. Median region narrowly swollen. Sulcus shallow, confined to anterior third, bounded by costae extending nearly to midvalve; sulcus occupied by single costa extending nearly to midvalve. Tongue short, angularly bilobed.

Dorsal valve flatly convex in side view with greatest convexity at umbo. Anterior profile forming rounded dome with steep sides, doming somewhat less than that of ventral valve. Umbonal and median regions moderately swollen; Fold narrow, confined to anterior third consisting of two costae bounding deep, short median groove. Costae not quite reaching midvalve.

Interior: Ventral valve not seen. Dorsal valve known from incomplete loop, with angle of 30°, occupying 2/5 valve length, slightly more than 1/3 valve width. Cardinal process small, semielliptical shelf. Socket ridges thin, narrow; outer hinge plates short, narrow, tapered for short distance just above (ventrad) dorsal margin of crural base. Crural processes located posterior of midloop. Descending lamellae bowed laterally. Transverse band not preserved.

MEASUREMENTS (in mm).—USNM 380471a: length 29.4, dorsal valve length 24.0, width 21.6, thickness 19.2, apical angle about 90°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1167.

SPECIMENS EXAMINED.—USNM 380471a,b.

DISCUSSION.—The external form of this species accords well with that of *Stiphrothyris*, but there is a difference in the ventral beak, which rests on the dorsal umbo, unlike that of true *Stiphrothyris*. The loop, what there is of it, is also different from that of *S. tumida* (Davidson, 1878:149), which is wider and has the crural processes located far anterior of midvalve.

Stiphrothyris? species 2

PLATE 31: FIGURES 7–12

DESCRIPTION.—This species resembles *Stiphrothyris* species 1 in its exterior but differs in larger size, less carinate ventral umbo, larger foramen, suberect beak, more swollen dorsal valve, wider anterior costae, which extend beyond midvalve.

MEASUREMENTS (in mm).—USNM 380387a: length 29.9, dorsal valve length 25.3, width 23.0; thickness 20.7, apical angle 71°.

GEOLOGIC OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1695.

SPECIMENS EXAMINED.—USNM 380387a,b.

Striithyris Muir-Wood, 1935

Striithyris costata, new species

PLATE 30: FIGURES 1–4

DIAGNOSIS.—Small *Striithyris* with strong costae secondarily developed.

DESCRIPTION.—Small narrowly ovate; maximum width slightly anterior of midvalve. Ventral valve deeper than dorsal valve. Specimen laterally crushed. Anterior narrowly rounded, sides broadly rounded; apical angle acute. Anterior commissure sulciplicate. Beak short, labiate concealing symphytium. Foramen large, permesothyridid. Semicostate, 5 costae on a side extending to midvalve, median costa on fold; entire surface capillate.

MEASUREMENTS (not accurate because of lateral crushing) (in mm).—USNM 380423: length 22.5, dorsal valve length 18.7; width 14.3?, thickness 18.0?, apical angle 55°?.

OCCURRENCE.—Tuwaiq Mountain Formation: S1309.

TYPE.—Holotype: USNM 380423.

DISCUSSION.—The single specimen of this species differs from other *Striithyris* in the presence of strong lateral costae

extending for half the valve length. The few other specimens of *Striithyris* from the Tuwaiq Mountain Formation show no tendency toward costation other than the median wrinkling of the anterior commissure. It is interesting to note that other terebratulaceans from this formation have a tendency to wrinkled peripheries: new genera *Dissoria* and *Pleuraloma*.

Striithyris saudiarabica, new species

PLATE 30: FIGURES 8–12

DIAGNOSIS.—Small, narrowly ovate *Striithyris* with incipient sulciplication.

DESCRIPTION.—Small to medium, elongate oval, narrow; maximum width anterior to midvalve. Anterior and lateral margins rounded; posterolateral margins straight, forming acute angle. Anterior commissure rectimarginate to uniplicate in young, sulciplicate in adult. Beak short, labiate; foramen large, permesothyridid. Surface finely, evenly capillate.

Ventral valve gently convex in lateral view, moderately roundly domed with steep sides in anterior view. Umbonal, median and anterior regions swollen. Sulcus originating at about $^2/_3$ valve length from beak, shallow, narrow, occupied by low rounded costa. Tongue short, narrowly bilobed.

Dorsal valve gently convex in side view, less convex than ventral valve; anterior profile forming moderately convex dome with steep sides, similar to same view of ventral valve. Umbonal, median and anterior regions swollen. fold formed by 2 costae confined to anterior third or indistinctly continued to midvalve or beyond.

Interior: Ventral valve with short excavate pedical collar. Other details not preserved.

OCCURRENCE.—Tuwaiq Mountain Formation: S296.

TYPE.—Holotype: USNM 380230.

DISCUSSION.—This species is much smaller, narrower, and more strongly folded anteriorly than the large *Striithyris somaliensis* Muir-Wood (1935:129) from the Argovian (upper Oxfordian) of the Somali Republic.

Striithyris saudiarabica is similar in size to *Striithyris* from Callovian–Oxfordian beds of southern Israel (Hudson, 1958).

Striithyris striata, new species

PLATE 30: FIGURES 13–23

Striithyris somaliensis.—Cooper, 1983:153, pl. 37: figs. 9–14. [Not *Striithyris somaliensis* Muir-Wood, 1935].

DIAGNOSIS.—*Striithyris* with faintly developed anterior folding and fine costellae.

DESCRIPTION.—Small to medium, elongate oval, longer than wide, sides gently convex, anterior rounded, apical angle acute. Lateral commissure straight; anterior commissure gently sulciplicate. Beak suberect, foramen large, mesothyridid. Finely costellate.

Ventral valve gently convex in lateral view, moderately domed in anterior view. Sulcus shallow, starting at or anterior to midvalve, occupied by low, poorly defined fold. Tongue short bilobed.

Dorsal valve, gently convex in side view, moderately domed, doming slightly greater than that of ventral valve. Fold short, confined to anterior quarter or third, low, marked by short sulcus.

Loops described by Cooper (1983:153, pl. 37: figs. 12–14).

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380629a	21.0	17.6	14.6	15.0	70
380235	21.6	18.0	16.2	14.7	70
380639	22.4	18.4	14.6	16.4	71

OCCURRENCE.—Upper Dhruma Formation (probably Hisyan Member): S1615. Tuwaiq Mountain Formation: S154, S1198, S1199, S1458.

TYPES.—Holotype: USNM 380235. Paratypes: USNM 380629a,b, 380639, 551008a,b, 551009.

DISCUSSION.—This species is distinguished from *Striithyris saudiarabica*, new species, by its wider form, finer costellation, and less strong folding.

Tanyothyris, new genus

TYPE SPECIES.—*Tanyothyris angustata*, new species.

DIAGNOSIS.—Narrowly elongate oval, smooth gently rounded sides, ventral valve more convex than dorsal valve; uniplicate. Beak large, erect, resting on dorsal umbo. Foramen large, mesothyridid. Loop occupying nearly $^1/_2$ valve length, $^1/_3$ valve width. Crural processes anterior to midloop; terminal points moderately long.

OCCURRENCE.—Callovian.

ETYMOLOGY.—Greek *tanyo* (stretch out, long).

DISCUSSION.—This species is characterized by its smooth, elongate, narrow form and its uniplicate folding, which is unusual in Mesozoic terebratulids. In exterior form it resembles *Dorsoplicathyris* Almeras (1971) and *Arcelinithyris* Almeras (1971); the former is broadly sulcate and the latter has a loop with exceptionally long terminal points. Although its exterior resembles *Lissajousithyris* Almeras (1971) in its elongate form, *Tanyothyris* differs in folding and loop characters. *Lissajousithyris* has an unusually long loop, whereas that of *Tanyothyris* is short.

Tanyothyris angustata, new species

PLATE 30: FIGURES 25–30

DIAGNOSIS.—Narrowly elongate *Tanyothyris* with large foramen.

DESCRIPTION.—Large, longitudinally elliptical, with length

almost twice width. Maximum width just anterior of midvalve. Anterior narrowly rounded, sides gently convex, apical angle acute. Anterior commissure gently uniplicate. Beak long, thick, erect, concealing symphytium. Foramen large, mesothyridid. Smooth.

Ventral valve moderately convex in side view, most convex at umbo. Anterior profile forming narrow, steep-sided dome. Umbonal and median regions swollen. Sulcus a mere flattening of the anterior third. Tongue short, anterior nearly straight.

Dorsal valve evenly, gently convex in side view; forming high rounded, steep-sided dome in anterior view, dome steeper than that of ventral valve. Median region swollen. Fold low, barely perceptible in anterior third.

Interior: Ventral valve not seen. Dorsal valve with small cardinal process. Loop longer than wide, about 1/2 valve length, 1/3 valve width. Socket ridges, thin erect, bounding narrow sockets. Outer hinge plates short, narrowly triangular, dorsally attached; crural bases not well diffentiated from crural processes which form blunt, acute angles directed ventrally; Crural processes anterior of midloop. Descending lamellae short, laterally bowed. Transverse band broad at base narrowing to flattened, protuberant crest.

LOOP STATISTICS.—USNM 380477e: angle = 35°; W1/L1 = 0.64; L1/LD = 0.49; W1/WD = 0.34; a/L1 = 0.56; b/L1 = 0.44; c/L1 = 0.23; d/L1 = 0.33; e/L1 = 0.17; f/L1 = 0.27; g/WD = 0.35; g/W1 = 1.04; h/f = 0.30; h/L1 = 0.08; WD/LD = 0.87.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380476a	30.0	24.6	18.7	16.4	42
380476b	27.5	22.0	20.0	16.0	47
380476c	29.6	23.2	18.6	17.5	48
380476d	23.7	18.5	15.3	13.3	42

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380476a. Paratypes: USNM 380476b–e.

DISCUSSION.—This species is elongated and narrow with a very large foramen and elongate beak. Its sides are gently rounded. It differs from *Stenorina*, new genus, a long narrow form, which is strongly sulciplicate and which is more strongly folded than *Tanyothyris*. It differs from *T. symmetrica*, new species, in its larger size, somewhat narrower form with maximum width slightly anterior of midwidth. The foramen is larger and more circular with less labiation than that of *T. symmetrica*.

Tanyothyris symmetrica, new species

PLATE 30: FIGURES 31–36

DIAGNOSIS.—Small *Tanyothyris* with well-rounded sides and incipient sulciplication.

DESCRIPTION.—Medium, elongate oval, maximum width at about midvalve. Anterior rounded, sides moderately rounded, apical angle acute. Beak moderately long, labiate concealing symphytium. Foramen large, permesothyridid. Anterior commissure with incipient sulciplication. Smooth.

Ventral valve moderately convex in lateral view, forming moderately high, steep-sided dome in anterior view. Median region swollen. Anterior flattened forming short slightly rounded tongue.

Dorsal valve flatly convex in side view, forming low broad dome in anterior profile. Median region swollen. Anterior flattened to form low barely perceptible fold with slight anteromedian depression.

Interior: Ventral valve not seen. Dorsal valve with small semielliptical cardinal process. Length-width relationship of dorsal valve to loop not determined because of incomplete margins of dissected specimen. Outer hinge plates short, dorsally attached. Crural processes anterior of midloop, sharply pointed. Transverse band strongly arched, thick at base, thinning to narrow crest. Terminal points short.

LOOP STATISTICS.—USNM 380477b (margins of valves incomplete): angle = 37°; W1/L1 = 0.69; L1/LD = ?; W1/WD = ?; a/L1 = 0.62; b/L1 = 0.38; c/L1 = 0.38; d/L1 = 0.24; e/L1 = 12; f/L1 = 0.26; g/WD = ?; g/W1 = 1.01; h/f = 0.50; h/L1 = 0.14; WD/LD = ?.

MEASUREMENTS (in mm).—USNM 380477a: length 23.4, dorsal valve length 20.2, width 17.5, thickness 13.7, apical angle 64°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

TYPES.—Holotype: USNM 380477a. Paratype: USNM 380477b. DISCUSSION.—This species is shaped differently, has a strongly labiate foramen, and smaller size than its contemporary *T. angustata*, new species.

Toxonelasma, new genus

TYPE SPECIES.—*Toxonelasma arabicum*, new species.

DIAGNOSIS.—Small to medium, biconvex with swollen valves; subcircular to subpentagonal; gently sulciplicate. Beak short, foramen large, permesothyridid. Smooth. Dorsal valve interior with ventrally convex hinge plates. Loop longer than wide, occupying 1/3 valve length and width. Crural processes anterior of midloop. Terminal points short.

SPECIMENS STUDIED.—29.

GEOLOGIC OCCURRENCE.—Bajocian.

ETYMOLOGY.—Greek *toxon* (bow) plus *elasma* (plate), in allusion to the ventrad bowing of the hinge plates.

DISCUSSION.—This genus resembles *Conarothyris* Cooper, 1983, in its external form differing in its more rounded outline and details of the loop. The *Conarothyris* loop is longer, has the crural processes posterior rather than anterior as in *Toxonelasma*, and has shorter terminal points. *Toxonelasma* differs from *Gyrosina* in its more gentle folding and loop characters.

The plump valves of *Toxonelasma* suggest *Sphaeroidothyris* Buckman (1917) differing in fold and loop, those characters in *Sphaeroidothyris* sensu stricto, being rectimarginate anterior commissure and very wide loop.

Toxonelasma arabicum, new species

FIGURE 38; PLATE 24: FIGURES 17–23

DIAGNOSIS.—*Toxonelasma* with subdued folding.

DESCRIPTION.—Medium, roundly subpentagonal, slightly longer than wide; maximum width just anterior of midvalve. Ventral valve deeper than dorsal valve. Anterior rounded, sides rounded, apical angle variable. Anterior commissure moderately sulciplicate. Beak short, rounded, suberect to erect; foramen large, permesothyridid. Smooth, inner layer with concentric and fine radial lines crossing.

Ventral valve fairly strongly convex in side view, moder-

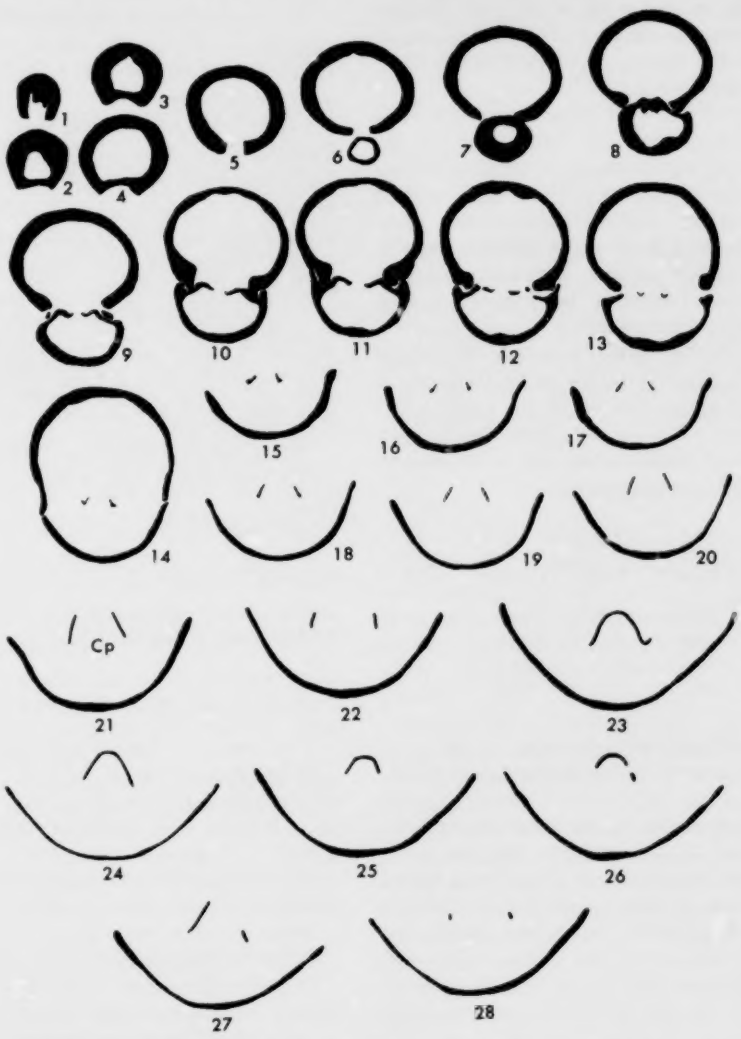

FIGURE 38.—*Toxonelasma arabicum*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.2(0.2); 2, 0.4(0.6); 3, 0.3(0.9) 4, 0.3(1.2); 5, 1.1(2.3), 6, 0.5(2.8); 7, 0.3(3.1); 8, 0.4(3.5); 9, 0.3(3.8); 10, 0.3(4.1); 11, 0.2(4.3); 12, 0.2(4.5), 13, 0.2(4.7); 14, 0.5(5.2); 15, 0.2(5.4); 16, 0.3(5.7); 17, 0.4(6.1), 18, 0.2(6.3); 19, 0.1(6.4); 20, 0.7(7.1); 21, 0.4(7.5) (Cp = crural process); 22, 1.2(8.7); 23, 0.3(9.0); 24, 0.2(9.2); 25, 0.2(9.4); 26, 0.1(9.5); 27, 0.3(9.8); 28, 0.2(10.00). Loop lost after 10 mm; approximately ×2; length 20.6 mm; length of dorsal valve 17.2 mm, width 17.0 mm; USNM 380645; Locality S1618.

ately domed with steeply sloping sides in anterior profile. Umbonal and median regions swollen. Sulcus marginal, shallow with short medial elevation. Tongue short, bilobed.

Dorsal valve unevenly convex in side view, with bulge at umbo; fairly strongly domed in anterior view with steeply sloping sides, doming stronger than that of ventral valve. Umbonal region inflated. Fold marginal, bounded by short costae separated by narrow shallow groove.

Interior: Hinge plates ventrally convex in section; outer hinge plates not strongly differentiated; crural processes anterior of midloop, moderately long; transverse band thick.

LOOP STATISTICS.—USNM 380645: angle = 36°; W1/L1 = 0.62; L1/LD = 0.36; W1/WD = 0.29; a/L1 = 0.64; b/L1 = 0.36; c/L1 = 0.23; d/L1 = 0.41; e/L1 = 0.19; f/L1 = 0.17; g/WD = 0.38; g/W1 = 0.87; h/f = 0.38 h/L1 = 0.07; WD/LD = 0.82; length of dorsal valve = 17.2.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380385a	14.6	12.8	14.3	10.2	99
380385b	18.0	15.6	16.4	14.4	84
380385c	18.3	16.0	17.0	14.3	85
380412a	22.0	18.8	20.0	15.5	88

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1485; S1618.

TYPES.—Holotype: USNM 380412a. Paratypes: USNM 380385a–c, 380412b, 380645.

DISCUSSION.—The specimens from Saudi Arabia differ from *Conarothyris opima* Cooper (1983) in having a shorter, smaller beak, in more reduced folding and larger apical angle. The loops of the two genera are quite different, that of *Toxonelasma* having the crural processes farther forward and the terminal points much shorter than those features in *Conarothyris*.

Family Uncertain

Dissoria, new genus

TYPE SPECIES.—*Dissoria costata*, new species.

DIAGNOSIS.—Uniplicate, elongate oval terebratulaceans with superposed costation.

SPECIMENS STUDIED.—5.

GEOLOGIC OCCURRENCE.—Callovian.

ETYMOLOGY.—Greek *dissos* (two-fold), in allusion to the two types of folding, the uniplicate and costate.

DISCUSSION.—This genus resembles *Pleuraloma*, new genus, and *Tanyothyris*, new genus, in general elongate oval form. It differs from the first in being uniplicate and in not having costae on the flanks. *Dissoria* differs from *Tanyothyris*, which is smooth and uniplicate in its costation of the median region. *Dissoria* differs from *Arapsopleurum*, new genus, in its strong uniplication, whereas *Arapsopleurum* is weakly sulciplicate.

Dissoria costata, new species

PLATE 25: FIGURES 1–4

DIAGNOSIS.—*Dissoria* with few strong costae.

DESCRIPTION.—Large, narrowly elongate oval; maximum width about midvalve. Ventral valve much deeper than dorsal valve. Anterior gently rounded, sides nearly straight, apical angle acute. Anterior commissure uniplicate. Beak erect, short, rounded, labiate. Foramen fairly large, mesothyridid. Symphytium mostly concealed. Posterior smooth, anterior strongly costate.

Ventral valve strongly convex in side view, moderately domed with precipitous sides in anterior profile. Umbonal and median regions strongly swollen. Sulcus wide, shallow, occupied by 2 strong costae extending posteriorly to midvalve; tongue long, trilobed.

Dorsal valve flatly convex in side view, anterior view forming low dome with short precipitous sides. Fold developed at anterior, short, marked by three short costae.

Interior: Ventral valve with short, excavate pedicle collar. Other details not seen. Dorsal valve with loop at least 1/3 valve length, about 1/3 valve width. Cardinal process forming short semielliptical shelf. Outer hinge plates narrow concave, tapered on dorsal edge of crural bases. Crural processes posterior of midloop. Transverse band and terminal points not preserved.

MEASUREMENTS (in mm).—USNM 380436: length 30.3, dorsal valve length 23.0, width 20.5, thickness 21.1, apical angle 48°, fold width 15.5.

OCCURRENCE.—Tuwaiq Mountain Formation: S1702.

TYPES.—Holotype: USNM 380436. Paratype: USNM 380464.

DISCUSSION.—Poorly silicified specimens yielded the little information given on interior characters. This species differs from *D. tribulis*, new species, in its larger size and stronger costation. It is of about the same size as *D. obscura*, new species, differing in its greater costation.

Dissoria obscura, new species

PLATE 25: FIGURES 28–30

DIAGNOSIS.—Sparsely costate *Dissoria*.

DESCRIPTION.—Large, narrowly elongate oval, maximum width at midvalve; ventral valve deeper than dorsal valve. Anterior narrowly rounded, sides gently rounded, apical angle acute. Anterior commissure uniplicate. Beak, rounded, labiate; foramen fairly large, permesothyridid; symphytium concealed. Smooth except for anterior costation.

Ventral valve strongly convex in side view, most convex in umbonal region; highly domed with gently convex crest, long precipitous sides in anterior profile. Umbonal and median regions strongly swollen. Sulcus broad, shallow, occupied by

2 low rounded costae extending posteriorly for 1/3 valve length. Tongue long, trilobed.

Dorsal valve flatly convex in side view, moderately strongly domed with short steep sides in anterior profile. Median region swollen. Fold in anterior third, broad, low, occupied by a single short costa.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380285a: length 31.5, dorsal valve length 26.2, width 21.0, thickness 19.4, apical angle 58°, fold width 14.7.

OCCURRENCE.—Tuwaiq Mountain Formation: S1702.

TYPES.—Holotype: USNM 380285a. Paratype: USNM 380285b.

DISCUSSION.—This species differs from *D. costata*, new species, which it approaches in size and form, in its lack of strong costae. It is larger and less costate than *D. tribulis*, new species, and much less narrowed at the beak than that species.

Dissoria tribulis, new species

PLATE 24: FIGURES 14–16

DIAGNOSIS.—Semicostate *Dissoria*.

DESCRIPTION.—Large, elongate oval, longer than wide, maximum width anterior to midvalve. Anterior margin rounded, sides rounded, apical angle acute. Anterior commissure uniplicate. Beak long, narrow, erect, labiate; symphytium concealed. Foramen large, mesothyridid. Surface semicostate, posterior smooth, anterior costate.

Ventral valve moderately convex, most convex in umbonal region in side view; moderately domed with precipitous sides in anterior profile. Median region swollen. Sulcus originating at midvalve, shallow, wide, occupied by 3 low, rounded costae. Flanks costate. Tongue moderately long, anteriorly serrate.

Dorsal valve moderately convex in side view with most convexity median; narrowly, strongly domed with steep slopes in anterior profile. Fold originating at midvalve, low, occupied by four costae. Flanks with 4 or more subdued costae.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380526: length 25.4, dorsal valve length 21.7, width 18.2; thickness 16.4, apical angle 49°.

OCCURRENCE.—Tuwaiq Mountain Formation: S296.

TYPE.—Holotype: USNM 380526.

DISCUSSION.—Although this species occurs with and suggests *Pleuraloma* new genus, its uniplicate anterior commissure precludes its placement in that genus. It seems closest to *Tanyothyris*, new genus, which is smooth. This is one among other species with smooth counterparts that have developed costae, like *Striithyris costata*, new species, and *Arabicella? costata*, new species, all occurring in the Tuwaiq Mountain Formation.

Kutchithyris Buckman, 1917

Kutchithyris? species 1

PLATE 27: FIGURES 7–9

Large, roundly subpentagonal, maximum width anterior of midvalve; anterolateral extremities narrowly rounded; anterior narrowly subtruncate; apical angle variable. Anterior commissure narrowly sulciplicate. Beak low, pressed close to dorsal umbo concealing symphytium. Foramen large, mesothyridid. Smooth.

Ventral valve gently convex in side view; broadly domed with moderately steep sides in anterior profile. Median region swollen. Sulcus confined to short tongue occupied by narrow costa.

Dorsal valve unevenly convex in side view, posterior and median regions fairly strongly convex, anterior flattened to concave in side view; anterior profile forming high rounded dome with long steeply sloping sides. Median and umbonal regions strongly swollen. Fold in anterior third consisting of 2 short narrowly rounded costae separated by narrow short sulcus.

Interior not seen.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380437a	26.7	24.2	24.6	26.2	89
380437b	26.7	23.7	24.2	26.5	90

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): KK9-20; (*Dhrumaites* Zone): S1006. Tuwaiq Mountain Formation: S1476. Hanifa Formation: S1299.

SPECIMENS EXAMINED.—USNM 380437a,b.

DISCUSSION.—Published serial sections of the loop (Muir-Wood, 1965) indicate a long loop with long crural points (see discussion by Cooper, 1983:96).

Kutchithyris? species 2

PLATE 26: FIGURES 28–30

This species differs from the preceding in its narrower form, more acute apical angle, and stronger anterior plication.

MEASUREMENTS (in mm).—USNM 380415: length 28.1, dorsal valve length 25.0, width 23.3, thickness 27.0; apical angle 77°.

OCCURRENCE.—Tuwaiq Mountain Formation: S293.

SPECIMEN EXAMINED.—USNM 380415.

Terebratulacean Genus and Species Undetermined 1

PLATE 28: FIGURES 17–19

DESCRIPTION.—Medium, narrowly, longitudinally elliptical; maximum width anterior to midvalve. Ventral valve slightly deeper than dorsal valve. Anterior narrowly rounded, sides gently rounded; apical angle acute. Beak short, obliquely truncated, suberect, slightly labiate; foramen small, mesothyridid; symphytium partially exposed. Smooth, incremental growth lamellae concentrated near margins.

Ventral valve gently convex in side view, narrowly domed with moderately sloping sides in anterior profile. Umbonal and median regions narrowly swollen, swelling continued to anterior margin where it occupies short sulcus bounded by incipient costae. Tongue short, bilobed.

Dorsal valve flatly convex in lateral view, forming moderately high dome with precipitous sides in anterior profile. Median region swollen. Fold very short, marginal, with short median depression.

Interior not known.

MEASUREMENTS (in mm).—USNM 380237: length 25.2, dorsal valve length 22.5, width 17.6; thickness 14.4, apical angle 70°.

OCCURRENCE.—Hanifa Formation: KK10-25.5.

SPECIMEN EXAMINED.—USNM 380237.

DISCUSSION.—The form of this species is unique among the Saudi Arabian brachiopods. In absence of any knowledge of its interior, it is not possible to place it generically.

Terebratulacean Genus and Species Undetermined 2

PLATE 30: FIGURES 37–40

DESCRIPTION.—Large, roundly subpentagonal, maximum width at midvalve. Ventral valve deeper and more convex than dorsal valve. Anterior nasute, sides rounded, apical angle acute. Anterior commissure uniplicate. Beak narrow, erect, labiate; foramen small, mesothyridid. Symphytium partially exposed. Surface marked by faint costae for about half valve length.

Ventral valve moderately convex in side view, most convex at incurved umbo; anterior profile forming high dome with moderately sloping sides. Umbonal region narrowly swollen, swelling extending to anteror margin. Tongue, short, narrowly rounded.

Dorsal valve flatly convex in side view, forming low dome with moderately sloping sides, doming slightly less than that of ventral valve. Median region swollen, swelling continued to anterior forming narrow, low fold extended onto ventral tongue to form nasute anterior.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380421: length 26.4, dorsal valve length 21.8, width 21.4, thickness 14.4, apical angle 83°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone); S1167.

SPECIMEN EXAMINED.—USNM 380421.

DISCUSSION.—The rectimarginate anterior commissure suggests possible relationship to *Plectothyris* Buckman, 1917. The Saudi Arabian species is more extensively costate than usual in *Plectothyris*. In absence of information regarding the loop, this specimen cannot be placed in any known family.

Terebratulacean Genus and Species Undetermined 3

PLATE 31: FIGURES 28–31

DESCRIPTION.—Large, length slightly greater than width, nearly circular; maximum width at midvalve; Anterior and sides rounded, apical angle slightly obtuse. Anterior commissure gently sulciplicate. Beak low, narrowly rounded, erect. Foramen small, permesothyridid. Surface smooth.

Ventral valve fairly strongly convex in lateral view, roundly domed with steeply sloping sides and rounded crest in anterior profile. Median region strongly swollen, swelling continued to anterior margin where it is slightly projected as two small lobes. Sulcus not formed but indicated by anterior projections. Tongue short.

Dorsal valve unevenly convex, fairly strongly so in posterior half, flattened in anterior half in side view; anterior view forming broad dome, slightly less strongly elevated than that of ventral valve. Fold originating in anterior third, low, consisting of two costae separated by shallow sulcus, all occupying slightly more than half valve width.

Interior: Ventral valve not seen. Dorsal valve with short loop measuring about $^1/_3$ valve length and width. Transverse band arched, crest protuberant.

MEASUREMENTS (in mm).—USNM 380510: length 28.3, dorsal valve length 24.0, width 26.5, thickness 18.0, apical angle 93°, fold width 16.0.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1164, S1167.

SPECIMENS EXAMINED.—USNM 380510, 380540.

DISCUSSION.—Although the loop can be seen in the silicious filling, other than length and width, the more critical dimensions could not be obtained nor its family connection determined.

This species is similar to *Charltonithyris*? *bihenensis* Weir as figured by Muir-Wood (1935, pl. 11: figs. 2a–c) from the Callovian of Somali Republic. If differs however, in being of greater convexity of both valves, less nasute anterior, and less strongly folded anterior. Muir-Wood's specimen is Callovian not Bajocian like the Saudi Arabian specimen.

Uncertainty about details of the loop is brought about by the preservation of the specimen, which is silica filled. The trace of the loop was obtained by grinding away the matrix.

This specimen does not conform to the generic characters of *Charltonithyris* Buckman, 1917, nor to that figured by Muir-Wood. *Charltonithyris* has a nearly flat, shallow dorsal valve.

The loop and exterior of this brachiopod are suggestive of

Epithyris? *submaxillata* (Morris) as illustrated by Cooper (1983:77, pl. 39: figs. 22–28). This English species is unlike *Epithyris* in its folding and probably represents another genus or new genus.

Superfamily ZEILLERIACEA Allan, 1940

Zeilleriaceans are rare in the Marrat Formation, abundant in the Dhruma Formation, rare in the Tuwaiq Mountain Formation, and only one specimen, *Sphriganaria* species 2, is known from the Hanifa Formation. The new and peculiar *Apothyris*, new genus, occurs in the Marrat Formation (along with *Rugitela* Muir-Wood, 1936) and in the Dhruma and Tuwaiq Mountain formations, but it is not common. The earliest occurrence of *Rugitela* is in the Marrat Formation. *Zeilleria* Bayle, 1878, is represented by two specimens of uncertain character. *Mycerosia*, new genus, is a small almond-shaped zeilleriid. A similar species occurs in the Callovian of the Somali Republic. A single specimen of *Flabellothyris* E. Eude-Deslongchamps, 1884, occurs in the *Thambites* Zone of the Middle Dhruma Formation and is a link to the British and French Bathonian.

Eudesia King, 1850, has been identified in Saudi Arabia with *E. cardium* (Valenciennes, in Lamarck, 1819) the usual species recorded. The present study does not recognize *Eudesia cardium* in the Saudi Arabian sequence. The brachiopods so identified, and *Sphriganaria cardioides* (Douvillé, 1916), new combination, prove to be related but with less advanced internal details. The many Saudi Arabian species are assigned to the new genus *Sphriganaria*. Another eudesioid externally similar to *E. cardium* has an unusual cardinal process entirely unlike that of *Eudesia* and is here referred to the new genus *Xenorina*.

Two specimens of *Pseudoglossothyris? sulcata* Muir-Wood (1935:121, pl. 13: fig. 6a–c) [= *Aulacothyris sulcata* (Muir-Wood, 1935), new combination] from Abyssinia (USNM 380466a,b) answer closely to Muir-Wood's description and are in close accordance with her figures. Muir-Wood did not figure the interior but likened the exterior features to *Pseudoglossothyris* Buckman (1901), and stated that the anterior suggested an aulacothyrid rather than *Pseudoglossothyris*. Her surmize as to aulacothyrid (Zeilleriacea) affinities is corroborated by the specimens figured herein (Plate 30: figures 42–43), which have a well-marked median septum and an undivided hinge plate. The figured specimens, herein placed in *Aulacothyris*, come from Jurassic rocks, 6 miles north of Dire Daua, Abyssinia. Similar specimens to these can be expected in the Jurassic of Saudi Arabia.

SUPRA-GENERIC HIERARCHY OF SAUDI ARABIAN ZEILLERIACEA

Family ZEILLERIIDAE Allan, 1940

Flabellothyris Eudes Deslongchamps, 1884; *Mycerosia*, new genus; *Rugitela* Muir-Wood, 1936; *Zeilleria* Bayle, 1878

Family EUDESIIDAE Muir-Wood, 1965

Apothyris, new genus; *Sphriganaria*, new genus; *Xenorina*, new genus

Family EUDESIIDAE Muir-Wood, 1965

According to the definition of the Eudesiidae Muir-Wood (1965:H829), the "loop [is] zeilleriid, given off dorsally; adult cardinal process complicated in structure, hollow, with 2 small cavities, trilobed, prominent, and elevated above fused thickened hinge plates, which are commonly pierced by 3 small cavities; median dorsal septum and dental plates present; shell, biconvex, fully costate or costellate."

The cardinal process is not mentioned in the generic diagnosis. However, *Eudesia* is the only genus in the family. *Sphriganaria*, species of which have hitherto been identified as *Eudesia*, has no cardinal process and its hinge is uncomplicated. *Xenorina*, new genus, is a eudesioid, externally like *Eudesia*, with eudesioid cardinalia and cardinal process, long, bilobed, flattened, and entirely unlike that figured for *Eudesia* (Muir-Wood, 1965:H830, fig. 714). Illustrations of a large specimen (USNM 400919) of the widely misidentified species of *Eudesia cardium* (Valenciennes, 1819) (Figure 39; Plate 35: figures 55–59) from the Bathonian of Ranville, Calvados, France, are introduced for comparison with the eudesioids of Saudi Arabia.

Illustration and sections of the hypotypes (USNM 402735a–c) of *Eudesia cardioides* Douvillé (1916:64, pl. 7: fig. 17a,b) [= *Sphriganaria cardioides* (Douvillé), new combination] are introduced for comparison with those of *S. bramkampi*, new

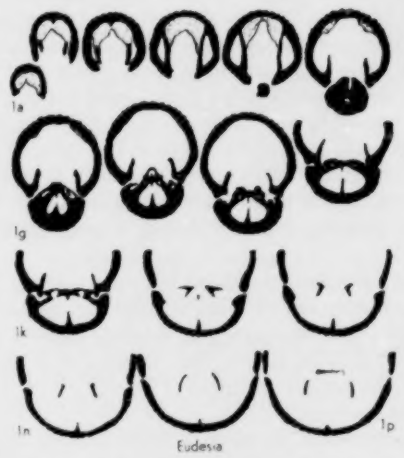

FIGURE 39.—*Eudesia cardium* (Valenciennes, 1819): Serial sections showing structure of cardinalia, from Muir-Wood (1965:H830; courtesy of Geological Society of America). [Introduced for comparison with serial sections of *Sphriganaria* and *Xenorina* (Figures 42–48).]

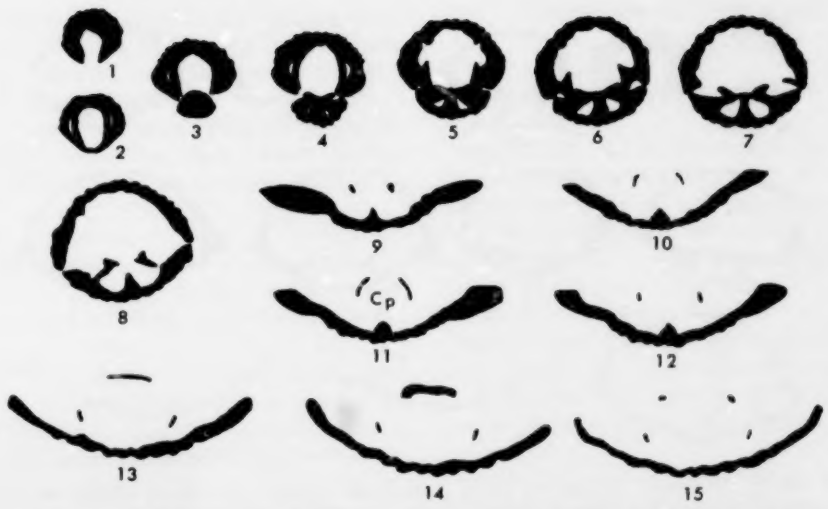

FIGURE 40.—*Sphriganaria cardioides* (Douvillé), new combination (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.7(0.7); 2, 0.4(1.1); 3, 0.5(1.6); 4, 0.4(2.0); 5, 0.5(2.5); 6, 0.4(2.9); 7, 0.4(3.3) 8, 0.4(3.7); 9, 0.3(4.0); 10, 0.6(4.6); 11, 0.2(4.8) (Cp = crural process); 12, 0.5(5.3); 13, 2.5(7.8); 14, 0.4(8.2); 15, 0.8(9.1). Approximately ×2.2; length 19.5 mm; USNM 402735c; Locality Gebel Enga Bash, Sinae Peninsula, Egypt.

species, and other Saudi Arabian species, as well as with *Eudesia cardium* (Valenciennes, 1918). *Eudesia cardioides* Rollier, 1919, was renamed *Eudesia rollieri* by Faraq (1960:69), which is quite different from Douvillé's species (Figure 40; Plate 35: figures1–10), which is from the Jurassic (lower Callovian), Jebel Enga Bash, Sinai Peninsula, Egypt.

Apothyris, new genus

TYPE SPECIES.—*Apothyris aberrans*, new species.

DIAGNOSIS.—Small Zeilleriacea with well-marked interareas, reduced dental plates, and cardinalia like those of *Sphriganaria*.

SPECIMENS STUDIED.—28.

GEOLOGIC OCCURRENCE.—Lias (Toarcian) to Callovian.

ETYMOLOGY.—Greek *apo* (away, from, off) plus *thyris* (opening), in allusion to its deviation from *Eudesia* and *Sphriganaria*.

DESCRIPTION.—Small, elongate oval to subcircular. Foramen large, mesothyridid; interarea defined by strong beak ridges. Deltidial plates conjunct or excavated. Costae irregular, narrow, separated by spaces as wide or wider than costae; intercalation in two or three generations.

Interior: Ventral valve with deltidial plates remnantal and very short dental plates. Dorsal valve with abbreviated eudesiid cardinalia, very short median septum supporting undivided hinge plate at apex; loop zeilleriid.

DISCUSSION.—This genus is separated from *Eudesia* and *Sphriganaria*, new genus, because of its well-marked, flat interarea, short median septum, numerous strong costae, intercalations, and aborted dental plates.

Apothyris aberrans, new species

FIGURE 41; PLATE 32: FIGURES 36–63

DIAGNOSIS.—Small, roundly oval with numerous cleft and intercalated costae.

DESCRIPTION.—Small, subcircular to roundly oval, inequivalve, dorsal valve less deep than ventral valve. Sides and anterior rounded, apical angle variable. Beak short, wide; foramen large, anteriorly excavated. Lateral commissure straight; anterior commissure slightly uniplicate. Costae strong, elevated, narrowly rounded, 12-18, with three generations of intercalation. Anterior lamellose.

Ventral valve moderately convex in side view, broadly, fairly strongly domed in anterior profile. Umbonal region swollen. Sulcus indistinct. Tongue short.

Dorsal valve flatly convex in side view, broadly, gently domed in anterior profile. Median region gently swollen. Fold indistinct formed by median costa and intercalated costae on either side, often slightly elevated above flanks. No regularity to costae. Flanks flatly convex, with gentle slopes.

Interior: Ventral valve with abbreviated dental plates, usually obscured by shell tissue. Dorsal valve with very short

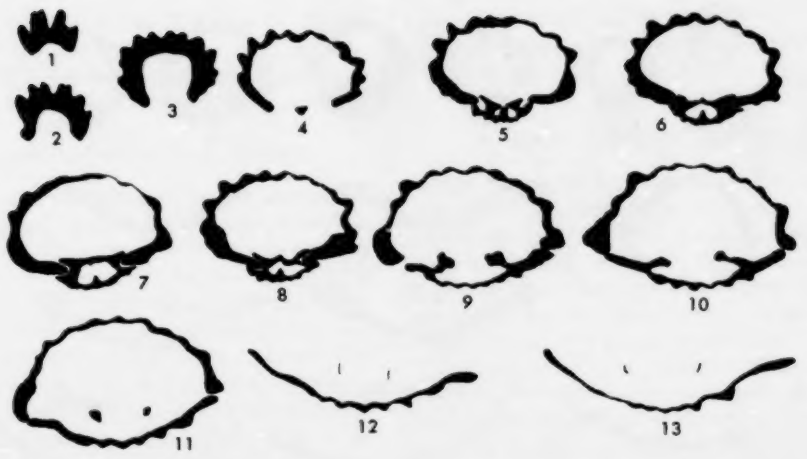

FIGURE 41.—*Apothyris aberrans*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.3(0.3); 2, 0.2(0.5); 3, 0.6(1.1); 4, 0.6(1.7); 5. 0.6(2.3); 6. 0.1(2.4); 7, 0.1(2.5); 8, 0.1(2.6); 9, 0.1(2.7); 10, 0.2(2.9); 11, 0.2(3.1); 12, 0.2(3.3); 13, 0.8(4.1). Specimen incomplete, not showing whole loop; approximately ×4; length 12.4 mm; USNM 380677; Locality S1462. [Very short dental plates in section 3 are close to shell wall of beak and covered by shell tissue, thus not appearing in the drawing.]

median septum supporting hinge plate at apex. Loop long, almost reaching the anterior; ascending branches about half loop length; crural processes blunt; transverse band flattened. (paratype USNM 380513b).

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates measurement not possible from imperfect specimen.

USNM	*Length*	*Dorsal valve length*	*Width*	*Hinge width*	*Thickness*	*Apical angle*
380311	15.0	13.0	15.0	10.0	8.0	93
380321a	12.2	10.5	11.7	6.8	7.2	94
380321c	13.4	11.4	11.6	5.5	6.5	84
380392a	15.3	13.0	14.0	7.0	8.3	83
380392b	14.3	12.3	13.4	7.6	8.0	88
380392c	14.6	12.1	12.5	7.8	7.5	?
380513a	17.5	12.7	16.0	11.5	11.5	93

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): S1244. Upper Dhruma Formation (Atash Member): KK9-112, -117, -122, -123; (Upper Atash–Lower Hisyan members): S1462; (Zone not placed): S1471. Tuwaiq Mountain Formation: S459.

TYPES.—Holotype: USNM 380392a. Paratypes: USNM 380311, 380321a–c, 380352, 380392b,c, 380513a,b, 380677.

DISCUSSION.—The aspect of this species is quite different from any *Eudesia* or *Sphriganaria*, because its hinge line, interareas, short dental plates, and median septum form a unique ensemble. The ornamentation is distinctive. The species is quite variable in shape, some specimens being nearly circular, others elongate or elongate elliptical.

Apothyris species

PLATE 18: FIGURES 1–6

DESCRIPTION.—A single specimen of this peculiar genus was taken from the Marrat Formation. The specimen is elongate oval, small with equally convex valves. The maximum width is anterior of midvalve. The beak is suberect and has a large foramen. This is the earliest record of *Apothyris*. It is more elongate and smaller than the later specimens of this genus.

MEASUREMENTS (in mm).—USNM 400921: length 10.0, dorsal valve length 8.4, width 8.3, thickness 5.5.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S989.

SPECIMEN EXAMINED.—USNM 400921.

DISCUSSION.—Specimen is possibly a float.

Sphriganaria, new genus

TYPE SPECIES.—*Sphriganaria modesta*, new species.

DIAGNOSIS.—Small to medium zeilleriids completely costate with short median septum posteriorly supporting a flat hinge plate without cardinal process.

DESCRIPTION.—Small to medium, oval to subtriangular; maximum width ranging from midvalve to anterior. Subequally biconvex, ventral valve usually slightly deeper than dorsal valve. Lateral commissure straight; anterior commissure

usually rectimarginate with tendency in some species to feeble uniplication, more rarely slight anterior emargination. Beak short, straight to erect; foramen round, large usually mesothyridid. Surface costate to costellate to lirate.

Interior: Ventral valve with short dental plates; pedicle collar sessile. Dorsal valve with short median septum supporting flattish hinge plates at the apex only. Loop as in Zeilleriidae.

SPECIMENS STUDIED.—Many.

GEOLOGIC OCCURRENCE.—Bajocian to Kimmeridgian.

ETYMOLOGY.—Greek *sphriganos* (bursting with health and vigor), in allusion to the abundant species and longevity of the genus.

DISCUSSION.—The members of this genus have usually been assigned to *Eudesia*, which they superficially resemble. The typical European *Eudesia* is a much larger form having a different interior with longer median septum and with hinge plate bearing an elaborate cardinal process. *Eudesia* is confined to the Bathonian according to Muir-Wood (1965:H830).

Sphriganaria is related to the new genus *Xenorina* in its general appearance and hinge plate, although it does not have the peculiar cardinal process of *Xenorina*.

Sphriganaria is one of the commonest brachiopods in the Jurassic of Saudi Arabia. it occurs throughout the Dhruma Formation, is rare in the Tuwaiq Mountain and Hanifa formations. It is fairly uniform in its internal characters; its exterior is variable, especially as regards the ribbing and shape. Many of the species have bifurcated and intercalated costae that make for a great variety of patterns. Most species are rectimarginate; occasional ones show a tendency toward uniplication. A number of species have elevated median costae on both valves that tend to form a modest nasute anterior margin. The variation in ribbing leads to a magnification of species, especially in small lots or single specimens. The collection from Saudi Arabia is uneven in the numbers of individuals from the various localities. There are many represented by one specimen only, some not described herein.

The Jurassic of the Sinai Peninsula, Egypt abounds in specimens of *Sphriganaria* with a variety of external details. Farag (1960) described nine species of *Eudesia* [= *Sphriganaria*] from the Sinai Peninsula. Unfortunately the plates illustrating the specimens have evidently been reduced so that there is a discrepancy between the enlargements given for the illustrations and the measurements of the specimens in the text. There seems to be a one-fifth reduction in size. The USNM collection contains a large number of *Sphriganaria* from Sinai. I have been able to recognize only one of the Sinai species in Saudi Arabia: *S. magharensis* (Farag), new combination.

It is interesting to note the abundance of *Sphriganaria* in the Jurassic of Sinai and Saudi Arabia and its absence or great rarity in the Jurassic of Israel, Somalia, and Ethiopia. *Sphriganaria* appears not to be present or is very rare in the Jurassic of southern Israel, although a species of *Striithyris* like that of Saudi Arabia is found there (Cooper, 1983:153).

Sphriganaria angulocostata, new species

PLATE 33: FIGURES 1–9

DIAGNOSIS.—Large ovate *Sphriganaria* with few strong angular costae.

DESCRIPTION.—Large, oval, ventral valve much deeper than dorsal valve. Maximum width anterior of midvalve. Sides and anterior rounded. Apical angle acute. Commissures straight. Beak short, narrow; foramen medium, permesothyridid. Costae strongly elevated, angular, distant, numbering about 12. Intercalations few, mainly umbonal.

Ventral valve strongly convex in side view, moderately roundly domed with steep slopes in anterior profile. Median region swollen. Two median costae form indistinct fold.

Dorsal valve flatly convex in side view, gently domed in anterior profile with gentle slopes. Median 3 costae elevated to form fold.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380335a	25.8	22.4	24.0	16.1	79
380536a	27.0	24.0	23.6	18.2	75

OCCURRENCE.—Dhruma Formation (*Dhrumaites* Zone): S1007; KK9-90; (Atash Member): S1478; (Zone not placed): S1743.

TYPES.—Holotype: USNM 380536a. Paratypes: USNM 380335a,b, 380536b.

DISCUSSION.—This species differs from *S. bramkampi*, new species, in its different shape and sparser ornament. It differs from *S. magnicostata*, new species, which it resembles, in its angular, sparse costation, and narrower apical angle.

Sphriganaria angustata, new species

Figure 42; PLATE 33: FIGURES 10–17

DIAGNOSIS.—Small *Sphriganaria* with strong costae, bifurcation and intercalation of costae on umbo.

DESCRIPTION.—Small, elongate oval, ventral valve deeper than dorsal valve; maximum width at midvalve. Sides broadly rounded, anterior narrowly rounded, apical angle acute. Commissures straight. Beak short, rounded, erect; foramen large, mesothyridid. Costae narrowly rounded, separated by spaces equal to costae; about 15. Bifurcation mostly umbonal, intercalation sporadic.

Ventral valve gently convex in side view, moderately domed with steep sides in anterior profile. At midvalve 2 costae stronger than those surrounding form fold with third costa depressed between larger two.

Dorsal valve gently convex in side view, roundly domed in

FIGURE 42.—*Sphriganaria angustata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak); 1, 1.6(1.6); 2, 1.2(2.8); 3, 0.3(3.1); 4, 0.3(3.4). Approximately ×3; length 15.2 mm; USNM 402737; Locality S1440.

anterior profile. Fold formed of 2 prominent costae at midvalve.

MEASUREMENTS (in mm).—USNM 380319a: length 16.3, dorsal valve length 13.8, width 13.4, thickness 11.4, apical angle 70°.

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1056; (*Thambites* Zone): S1440, KK8-30–35; (*Tulites* Zone): S1621; (Zone not placed): S1156, S1449, S1456.

TYPES.—Holotype: USNM 380319a. Paratypes: USNM 380319b, 402737.

DISCUSSION.—This species is similar to *S. distincta*, new species, differing in smaller size, rounder sides, and more convex valves.

Sphriganaria arguta, new species

PLATE 33: FIGURES 18–22

DIAGNOSIS.—Small *Sphriganaria* with long narrowly oval outline.

DESCRIPTION.—Small, narrowly ovate, sides gently rounded; anterior margin narrowly rounded; apical angle acute. Ventral valve deeper than dorsal valve. Beak narrow, erect; foramen large, mesothyridid, anteriorly excavated. Costae narrowly rounded, separated by spaces about equal in width to costae; 13 costae.

Ventral valve moderately convex in side view, narrowly, moderately domed in anterior profile. Median 3 costae strong, forming fold originating on umbo, moderately elevated above steep flanks.

Dorsal valve gently convex in side view, narrowly domed about equal to doming of ventral valve in anterior profile. Median 2 large costae form narrow fold elevated above steep, rounded flanks. Dorsal and ventral folds meet to form subnasute anterior.

MEASUREMENTS (in mm).—USNM 380504: length 20.2, dorsal valve length 17.0, width 14.0, thickness 13.7, apical angle 45°.

OCCURRENCE.—Dhruma Formation (Zone not placed): S1449.

TYPE.—Holotype: USNM 380504.

DISCUSSION.—This species differs from all those described herein by its narrow, slender form, its median large costae forming fold. *Sphriganaria distans*, new species, is narrow but wider than *S. arguta* and has more costae.

Sphriganaria bicostata, new species

PLATE 33: FIGURES 23–32

DIAGNOSIS.—Medium sized *Sphriganaria* with 2 prominent median costae on dorsal valve.

DESCRIPTION.—Medium, widely elongate oval, maximum width at about midvalve. Valves nearly equal in depth. Sides rounded, anterior margin rounded; apical angle acute. Commissures straight. Beak low, suberect; foramen large, mesothyridid. Costae rounded, distant, about 13 or 14. Few bifurcations or intercalations.

Ventral valve moderately convex in side view, forming low dome in anterior profile. Valve medially swollen. Three median prominent costae form indistinct fold.

Dorsal valve gently, evenly convex in side view, forming low dome with sloping sides in anterior profile. Fold formed of 2 prominant costae.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380362a	21.0	18.0	17.3	14.3	80
380363	20.7	17.6	17.0	13.5	74

OCCURRENCE.—Dhruma Formation (*Dorsetensia* Zone): KK7-10.5; (*Ermoceras* Zone): S1618; (*Thambites* Zone): KK7-134, KK8-6–KK8-38; (*Tulites* Zone): S1621; (Zone not placed): S1457. Tuwaiq Mountain Formation: S1476.

TYPES.—Holotype: USNM 380362a. Paratypes: USNM 380362b, 380363.

DISCUSSION.—This species is suggestive of *S. modesta*, new species, differing from it in having only 2 costae on the dorsal fold, whereas *S. modesta* has three. The costation pattern of *S. bicostata* is like that of *S. arguta*, new species. The narrow form and low apical angle of the latter readily separate the two.

Sphriganaria bramkampi, new species

FIGURE 43; PLATE 33: FIGURES 38–55, PLATE 37: FIGURES 32–36

DIAGNOSIS.—Large, widely oval, *Sphriganaria* strongly costate with flatly convex shells.

DESCRIPTION.—Large, widely oval to subtriangular, valves nearly equal in convexity. Sides and anterior rounded, apical angle acute. Commissures straight. Beak short, narrow; foramen medium to large, mesothyridid. Costate, costae strong, distant with scattered implantation and bifurcation, 12 to 15 in number.

Ventral valve gently convex in lateral profile, broadly convex in anterior view. Two prominent costae enclose 3 or more costae slightly elevated or flush with flanks to form indistinct fold.

Dorsal valve flatly convex in side view, broadly convex in anterior profile. Three to 4 costae form indistinct fold. Flanks gently convex.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380310a	29.0	26.3	26.7	16.7	75
380316	24.2	21.6	22.3	14.0	77
380331a	27.4	24.0	24.6	14.7	78
380332a	22.6	19.6	20.0	14.2	76
380332b	20.0	18.0	20.2	12.6	86

OCCURRENCE.—Dhruma Formation (*Dhrumaites* Zone): S1685, KK9-90, -97; (Atash Member): KK9-112; (Hisyan Member): S1237, S1445, S1724, S1676. Upper Dhruma Formation (Zone not placed): S1235, S1249, S1251, S1252, S1295, S1311. Tuwaiq Mountain Formation: S154, S1365.

TYPES.—Holotype: USNM 380310a. Paratypes: USNM 380310b, 380316, 380331a,b, 380332a–d, 380642a,b, 380644, 380661, 400930.

DISCUSSION.—This is one of the largest species of *Sphriganaria* so far found in Saudi Arabia. Specimens have hitherto been variously identified as *E. cardium* (Valenciennes,

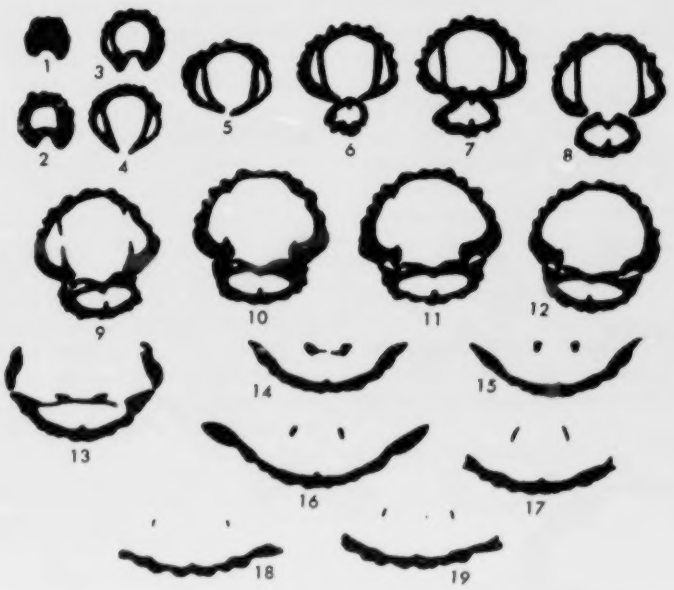

FIGURE 43.—*Sphriganaria bramkampi*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.4(0.4); 2, 1.0(1.4); 3, 0.2(1.6); 4, 0.3(1.9); 5, 0.4(2.3); 6, 0.4(2.7); 7, 0.4(3.1); 8, 0.4(3.5); 9, 0.4(3.9); 10, 0.3(4.2); 11, 0.2(4.4); 12, 0.4(4.8); 13, 0.4(5.2); 14, 03(5.5); 15 0.4(5.9); 16, 0.5(6.4); 17, 0.4(6.8); 18, 0.9(7.7); 19, 04.(8.1). Loop not complete; approximately ×1.5; length 21.9 mm; USNNM 380661; Locality S1676.

1819) and *E. cardioides* Douvillé, 1916 [= *Sphriganaria cardioides*]. *Sphriganaria bramkampi* is quite different from both of these species. It differs in shape and costation from *Eudesia cardium*, which is still larger and much more convex with strongly inflated valves (Plate 35: figures 55–59), usually without bifurcation or intercalation of costae. It differs from *Sphriganaria cardioides* from Sinai Peninsula, Egypt (Plate 35: figures 1–10) by its larger size, more triangular form and smaller apical angle.

Sphriganaria capax, new species

FIGURE 44; PLATE 35: FIGURES 32–37

DIAGNOSIS.—Medium to large *Sphriganaria* with strong costae with intercalation and bifurcation only on the umbones.

DESCRIPTION.—Medium to large, subtriangular, maximum width anterior of midvalve. Sides rounded, anterior margin nearly straight, apical angle acute. Commissures straight. Beak short, anteriorly excavated. Foramen large, mesothyridid. Costae subangular, somewhat crowded; bifurcation umbonal. Costae numbering 14.

Ventral valve moderately convex in side view, broadly, moderately domed with short steep sides in anterior view. Median region swollen. Median three costae slightly depressed to form shallow, narrow sulcus bounded by two slightly elevated costae.

Dorsal valve moderately convex in side view, slightly less convex than ventral valve; flatly domed with narrow, steep flanks in anterior profile. Faint narrow sulcus occupied by two depressed costae, bounded by one strong costa on each side. Sulcus on each valve forming slight median emargination of anterior.

MEASUREMENTS (in mm).—USNM 389338a: length 20.5, dorsal valve length 18.0, width 19.2, thickness 14.0, apical angle 78°.

OCCURRENCE.—Dhruma Formation (*Dhrumaites* Zone): KK9-95–96, -97, -98; (Hisyan Member): S1463; (Zone not placed): S1447. Upper Dhruma Formation (Zone not placed): S1295.

TYPES.—Holotype: USNM 380338a. Paratypes: USNM 380338b,c, 400924.

FIGURE 44.—*Sphriganaria capax*, new species: Section showing cardinalia of large specimen, approximately ×3, with thick dental plates, stout median septum supporting undivided hinge plate. No cardinal process. USNM 400924; locality uncertain, probably S1295.

DISCUSSION.—This is a large species with maximum width anterior of midvalve. It differs from *S. bramkampi*, new species, in its more crowded costae, smaller size, and more plump valves. It differs from *S. irregularis*, new species, in its narrower costae and more triangular outline. It is separated from *S. modesta*, new species, by its more expanded anterior and truncated anterior margin.

Sphriganaria concentrica, new species

PLATE 35: FIGURES 38–43

DIAGNOSIS.—Small, narrowly ovate *Sphriganaria* with concentric markings.

DESCRIPTION.—Small, elongate oval, maximum width anterior to midvalve, ventral valve slightly more convex than dorsal valve. Sides rounded, anterior margin truncate, apical angle acute. Commissures straight. Beak narrow, short, excavate anteriorly. Foramen large, mesothyridid. Costae strong, rounded, separated by spaces about equal in width to costae; about 14 costae. Surface with incremental growth imbrications.

Ventral valve gently convex in side view, moderately domed with short steep sides in anterior profile. Median region swollen. Two costae stronger than others bind 2 weaker ones to form indistinct fold.

Dorsal valve flatly convex in side view, broadly, moderately domed in anterior view. Umbonal and median regions swollen. Four strong costae forming poorly defined median fold opposing fold of ventral valve.

MEASUREMENTS (in mm).—USNM 380346: length 16.4, dorsal valve length 13.7, width 14.0, thickness 10.3, apical angle 67°.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK7-96; (*Dhrumaites* Zone): KK9-73–KK9-111.

TYPE.—Holotype: USNM 380346.

DISCUSSION.—This species somewhat resembles *S. costata*, new species. It is however, a little larger, plumper, and has distinct concentric imbrications lacking in the other species.

Sphriganaria costata, new species

PLATE 34: FIGURES 33–44

DIAGNOSIS.—Small, *Sphriganaria* with strong, distant costae.

DESCRIPTION.—Small, roundly oval, maximum width at midvalve, ventral valve deeper than dorsal valve; sides and anterior rounded; apical angle acute. Commissures straight. Beak low, suberect, complete; foramen large, mesothyridid. Costae strong, distant, up to 12 in number. Bifurcations and intercalations umbonal.

Ventral valve gently convex in side view, forming low steep-sided dome in anterior profile. Midregion swollen. Fold

formed by 3 or 4 slightly elevated costae.

Dorsal valve gently convex in side view forming flattish dome in anterior view. Median region moderately swollen. Flanks gently sloping.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle
380349a	14.5	12.7	13.4	8.5	77
380349b	14.1	12.5	13.2	9.2	77

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1157, S1440, KK8-6–KK8-38; (*Tulites* Zone): S1747, KK8-46; (Zone not placed): S1285.

TYPES.—Holotype: USNM 380349b. Paratypes: USNM 380349a,c,d.

DISCUSSION.—This is a small species with strong costae, resembling *S. parva*, new species, differing in its larger size and rounder shell.

Sphriganaria costellata, new species

FIGURE 45; PLATE 34: FIGURES 1–10

DIAGNOSIS.—Medium-size *Sphriganaria* with numerous fine costellae.

DESCRIPTION.—Medium, subpentagonal to roundly oval; valves nearly equal in depth: maximum width near midvalve. Sides rounded; anterior margin flatly rounded. Apical angle obtuse. Commissures straight. Beak low, suberect, anteriorly excavated; foramen large, mesothyridid. Finely costate to costellate, costae number 28, crowded.

Ventral valve moderately convex in side view, moderately broadly domed with fairly steep slope in anterior profile. No development of fold or sulcus.

Dorsal valve moderately convex in side view, moderately domed in anterior view with steep sides, doming more than that of ventral valve. Umbonal and median regions greatly swollen. No fold or sulcus.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle
380312	17.8	16.4	16.5	12.0	94
380354	20.7	18.5	19.6	14.0	85
400931a	20.0	17.0	18.0	14.6	80
400931b	17.6	16.0	16.8	10.6	85

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): KK8-3.8; (*Thambites* Zone): S1001, S1046, S1160, KK8-34, -30–35; (*Tulites* Zone): KK8a-43. (*Micromphalites* Zone): KK9-30–40; (Zone not placed): S1119, S1156, S1274.

TYPES.—Holotype: USNM 400931a. Paratypes: USNM 380312, 380354, 400931b, 402736.

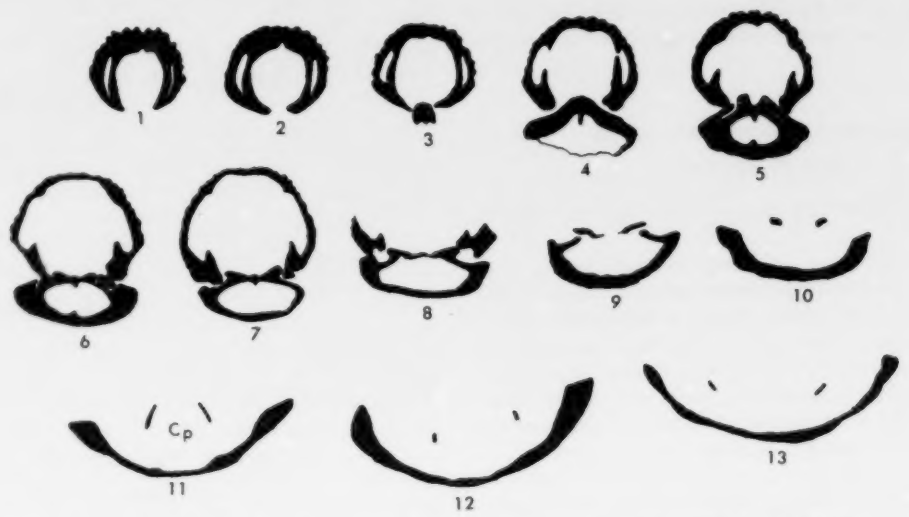

FIGURE 45.—*Sphriganaria costellata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 1.4(1.4); 2, 0.5(1.9); 3, 0.6(2.5); 4, 0.4(2.9); 5, 0.4(3.3); 6, 0.3(3.6); 7, 0.4(4.0); 8, 0.3(4.3); 9, 0.5(4.8); 10, 0.2(5.0); 11, 1.1(6.1) (Cp = crural process); 12, 0.8(6.9); 13, 0.3(7.2); approximately ×2.5; length 15 mm; USNM 402736; Locality KK8-30-35.

DISCUSSION.—This species is larger than *S. magharensis* (Farag), new combination, and is distinguished by its fine costae or costellae.

Sphriganaria curtirostra, new species

PLATE 33: FIGURES 33–37

DIAGNOSIS.—Medium-size *Sphriganaria* with narrowly rounded, distant costae, strongly truncate beak.

DESCRIPTION.—Medium, roundly oval, maximum width at midvalve; Sides rounded, anterior broadly rounded; apical angle acute. Commissures straight. Beak short, strongly truncated, at about level of dorsal umbone, anterior excavated. Foramen large; no deltidial plates. Costae narrowly rounded, separated by spaces wider than costae. Bifurcations and intercalations few, mostly at beaks, occasionally on flanks. Costae numbering 13.

Ventral valve of about same depth as dorsal valve, gently convex in side view, moderately domed in anterior profile. Median three costae stronger than those on flanks, forming indistinct fold.

Dorsal valve gently convex in side view, broadly, moderately domed in anterior view, doming flatter than that of ventral valve. Median two costae larger than flanking costae, forming indistinct fold and slight anterior protuberance.

MEASUREMENTS (in mm).—USNM 380500: length 16.4, dorsal valve length 15.8, width 16.2, thickness 10.2, apical angle 72°.

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): S743.

TYPE.—Holotype: USNM 380500.

DISCUSSION.—The recessive, truncated beak and distant costae separate this species from all *Sphriganaria* described herein.

Sphriganaria distans, new species

PLATE 35: FIGURES 44–49

DIAGNOSIS.—Extremely narrow *Sphriganaria* with low apical angle.

DESCRIPTION.—Small, elongate, narrowly oval, valves nearly equal in depth. Sides rounded; anterior margin slightly nasute, apical angle acute. Anterior commissure faintly, narrowly sulcate. Beak fairly long, suberect, anteriorly excavate. Foramen large, mesothyridid. Costae 13 in number, narrowly rounded separated by spaces wider than costae. Intercalation and bifurcation in three generations, one near beak, second near midvalve, third incipient at margin.

Ventral valve evenly, gently convex in side view, narrowly, moderately domed in anterior profile, doming about equal to that of dorsal valve. Median 3 costae forming indistinct fold. Flanks rounded, steep.

Dorsal valve moderately convex in side view, moderately domed with steep sides in anterior view. Median 4 costae forming indistinct fold, which, with ventral fold, produces anterior protuberance and suggestion of sulcation.

MEASUREMENTS (in mm).—USNM 380507: length 17.0, dorsal valve length 14.6, width 11.9, thickness 10.3, apical angle 58°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): KK7-131.

TYPE.—Holotype: USNM 380507.

DISCUSSION.—This species in its narrowly elliptial, elongate form is most like *S. arguta*, new species, differing importantly in its smaller size, more narrowly rounded costae, and more intercalations and bifurcations of the costae. Like the larger *S. varicostata* and *eximia*, both new species, this form has similar narrowly rounded costae, suggesting relationship among the three species.

Sphriganaria distincta, new species

PLATE 34: FIGURES 17–27

DIAGNOSIS.—Medium, narrowly elongate oval *Sphriganaria* with prominent median costae on dorsal valve.

DESCRIPTION.—Medium, narrowly elongate oval; maximum width anterior to midvalve. Ventral valve deeper than dorsal valve. Sides broadly rounded; anterior narrowly rounded, slightly nasute. Apical angle acute. Beak short, suberect, excavate. Foramen large, mesothyridid. Costae broadly rounded distant, numbering up to 15. Intercalations and bifurcation in three generations.

Ventral valve gently convex in side view, somewhat narrowly domed with steep slopes in anterior profile. Umbonal and median regions swollen. Median three large costae forming distinct fold.

Dorsal valve flatly convex in lateral view, forming a flattened dome in anterior view. Umbonal and median regions moderately swollen. Fold of 2 strong costae meeting ventral fold of 3 costae in slight protuberance.

MEASUREMENTS (in mm).—USNM 380340: length 19.3, dorsal valve length 17.0, width 15.0, thickness 11.4, apical angle 60°.

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): KK7-132; (*Thambites* Zone): S1440; KK8-23; (*Tulites* Zone): S1283, KK8a-43; (Zone not placed): S1449.

TYPES.—Holotype: USNM 380340. Paratypes: USNM 380320a,b.

DISCUSSION.—This species is closest to *S. bicostata*, new species, differing from it in smaller size and narrower form.

Sphriganaria elliptica, new species

PLATE 34: FIGURES 28–32

DIAGNOSIS.—Almond-shaped *Sphriganaria*.

DESCRIPTION.—Small, longitudinally elliptical, maximum width at midvalve. Ventral valve slightly more convex than dorsal valve. Sides gently rounded, anterior margin narrowly

truncated; apical angle acute. Commissures straight. Beak short, narrow, truncated. Foramen large, narrowly excavated anteriorly, mesothyridid. Costae low, rounded, numbering 17.

Ventral valve gently convex in side view, forming steep-sided narrow dome in anterior profile. Valve strongly swollen medially. Two costae stronger than others bounding three smaller costae depressed to form shallow sulcus.

Dorsal valve flatly convex in side view, forming low dome in anterior view. Umbonal and median regions swollen. Two strong costae bound two lesser ones to form narrow sulcus producing anterior truncation.

MEASUREMENTS (in mm).—USNM 380343: length 18.3, dorsal vlave length 16.0, width 13.7, thickness 11.2, apical angle 65°.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1001.

TYPE.—Holotype: USNM 380343.

DISCUSSION.—*Sphriganaria elliptica* differs from *S. distincta*, new species, in its strong costae and difference in costation, as it lacks the 2 thick costae on the ventral valve so prominent on *S. distincta*. It is also more narrowly rounded than *S. distincta* and more numerously and finely costate than *S. arguta* and *S. distans*, new species, both of which are very narrow. Its extremely narrow form and stronger costae distinguish this species from *S. perovalis*, new species.

Sphriganaria eximia, new species

PLATE 35: FIGURES 50–54

DIAGNOSIS.—Subpentagonal *Sphriganaria* with very narrowly rounded costae with numerous intercalations and bifurcations; nasute anterior.

DESCRIPTION.—Medium, subpentagonal, longer than wide with maximum width at midvalve; ventral valve slightly deeper and more convex than dorsal valve. Sides rounded, anterior nasute. Apical angle acute. Beak short, suberect. Foramen large, permesothyridid. Costae very narrowly rounded, separated by spaces wider than costae. Numerous intercalations and bifurcations occurring on umbones. Costae numbering 25.

Ventral valve moderately and evenly convex in side view, moderately domed with steep flattened sides in anterior profile. Median region swollen from beak to anterior margin forming indistinct fold.

Dorsal valve gently convex, most convex in posterior half in side view, slightly less strongly domed than ventral valve in anterior view. Median region from beak to anterior slightly swollen to form indistinct fold, producing with ventral swelling, nasute anterior.

MEASUREMENTS (in mm).—USNM 380506: length 21.0, dorsal valve length 18.4, width 18.0, thickness 12.6, apical angle 80°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1162.

TYPE.—Holotype: USNM 380506.

DISCUSSION.—This species is similar to *S. varicostata*, new species, and occurs in the same zone. It is however, quite different from that species in its costation, the costae being more narrowly rounded and the concentric markings of *S. varicostata* are not present. There is also a small difference in shape, and *S. eximia* has less plump valves than *S. varicostata*.

Sphriganaria expansa, new species

FIGURE 46; PLATE 34: FIGURES 45–59

DIAGNOSIS.—Widely triangular *Sphriganaria* with numerous costae.

DESCRIPTION.—Large, widely triangular, ventral valve slightly deeper than dorsal valve. Maximum width anterior of midvalve. Anterolateral extremities rounded, posterolateral extremities straight, forming acute apical angle. Commissures straight. Beak short, narrow, slightly incurved, anterior excavated. Foramen large, mesothyridid. Costae narrowly rounded, intercalations mostly posterolateral, numbering 23.

Ventral valve moderately convex, most so in umbonal region, in side view; anterior profile forming broad, moderately high dome with steep sides and slight median depression. Umbonal and median regions swollen. Two costae, stronger than ones on flanks bound slightly depressed sulcus with four costae.

Dorsal valve flatly convex in side view, forming broad low dome with moderately steep sides in anterior profile. Two costae of the umbonal region are swollen and stronger than those on flanks, which bind the slightly raised area of 3 costae, all of which form an inconspicuous fold.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380317a	21.9	19.0	21.4	13.4	78
380317b	22.7	19.7	20.8	14.0	74
380355	20.4	18.0	19.6	12.0	78

OCCURRENCE.—Upper Dhruma Formation (Atash Member): S1478. (Hisyan Member): S1444; (Zone not placed): S1742.

FIGURE 46.—*Sphriganaria expansa*, new species. Section cut to show cardinalia, ×2; USNM 400925; probably Locality S1742.

TYPES.—Holotype: USNM 380317b. Paratypes: USNM 380317a, 380355, 400925.

DISCUSSION.—This species attains the size of *S. bramkampi*, new species, and is distinguished from that species by its much finer costation. It differs from *Xenorina ovata*, new species, in its more triangular outline, and less swollen valves.

Sphriganaria intercalata, new species

PLATE 34: FIGURES 60–65

DIAGNOSIS.—Small, nearly circular *Sphriganaria* with numerous intercalations and bifurcations; beak low.

DESCRIPTION.—Small, nearly circular, maximum width at midvalve. Sides and anterior strongly rounded; apical angle acute. Commissures straight. Beak low, slightly incurved, anteriorly excavated; foramen large. Costae narrowly rounded, numbering 25, with intercalations at beak and midvalve.

Ventral valve gently convex in side view, fairly strongly domed with long steep slopes in anterior view. Median region swollen. No fold or sulcus.

Dorsal valve flatly convex, most so in umbonal region in side view forming low dome with gentle slopes in anterior profile. Umbonal and median regions gently swollen. No fold or sulcus.

MEASUREMENTS (in mm).—USNM 380336: length 16.4, dorsal valve length 15.0, width 16.7, thickness 9.5, apical angle 83°.

OCCURRENCE.—Upper Dhruma Formation (Hisyan Member): S1453.

TYPE.—Holotype: USNM 380336.

DISCUSSION.—Small size, widely subcircular shell, and numerous intercalations separate this species from all those described herein.

Sphriganaria irregularis, new species

PLATE 34: FIGURES 66–70

DIAGNOSIS.—Large roundly oval *Sphriganaria* with plump valves, broadly rounded costae with anterior intercalations.

DESCRIPTION.—Large, roundly oval, maximum width at midvalve; Ventral valve more convex than dorsal valve. Sides rounded, anterior margin slightly nasute; apical angle acute. Commissures straight. Beak short, narrow, suberect, anteriorly excavated; foramen large, permesothyridid. Costae broadly rounded, crowded, number 21 around margin.

Ventral valve fairly strongly convex in side view, broadly domed with steep lateral slopes. Median region swollen. Two strong costae bounding somewhat depressed median area of three costae at midvalve to form slight anterior tongue.

Dorsal valve moderately convex in side view, broadly domed with moderately steep slopes in anterior profile. Umbonal and median regions swollen. Median fold consisting of 2 strong costae bounding group of 4.

MEASUREMENTS (in mm).—USNM 380313a: length 23.5, dorsal valve length 20.3, width 20.0, thickness 15.6, apical angle 86°.

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1167; (*Thambites* Zone): KK8-7.

TYPES.—Holotype: USNM 380313a. Paratype: USNM 380313b.

DISCUSSION.—The irregular arrangment of the strong, widely rounded costae separates this species from *Xenorina ovata*, new species, which has plump valves. It is more strongly biconvex than *S bramkampi*, new species, which is about the same size although more triangular. It differs from *S. magnicostata* and *S. angulocostata*, new species, both of which are large plump forms, in having more numerous costae and more narrowly oval form.

Sphriganaria lirata, new species

PLATE 34: FIGURES 11–16

DIAGNOSIS.—*Sphriganaria* with numerous fine costellae.

DESCRIPTION.—Medium, subpentagonal, subequally convex, ventral valve slightly deeper than dorsal valve. Anterior margin subtruncate, sides gently rounded, apical angle 91°. Commissures straight. Beak short, suberect; foramen large, anteriorly excavated. Interarea large. Costellate, costellae numbering 37. Bifurcation and intercalations on umbones and near midvalve.

Ventral valve gently convex in side view, broadly, gently domed in anterior profile. Lateral slopes short, moderately steep. Anteromedian region with shallow, narrow depression.

Dorsal valve evenly, gently convex in side view, moderately domed in anterior view, doming greater than that of ventral valve. Umbonal and median regions swollen. Anterior median region with shallow depression, forming, with that of ventral valve, slight anterior emargination.

Interior not seen.

MEASUREMENTS (in mm).—USNM 380442: length 20.8, dorsal valve length 18.4, width 19.2, thickness 13.0, apical angle 91°.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone); S1160.

TYPE.—Holotype: USNM 380442.

DISCUSSION.—This species is distinguished from all other Saudi Arabian *Sphriganaria* in its very finely costellate exterior. It differs from *Eudesia infrabathonica* Fischer (1964), which is costellate, in its still finer costellation, less anterior intercalations of costellae. Its costellation is finer than that of *S. costellata*, new species.

Sphriganaria magharensis (Farag), new combination

PLATE 35: FIGURES 11–31; PLATE 37: FIGURES 22–31

Eudesia cardium.—Douvillé, 1916, pl. 7: figs. 13–15 [not *Eudesia cardium* (Valenciennes, 1819) = *Terebratula cardium* Valenciennes, 1819].

Eudesia magharensis Farag, 1960:67, pl. 1: fig. 4.

DESCRIPTION.—Medium, widely to elongate oval. Ventral more convex than dorsal valve. Sides and anterior rounded; apical angle acute. Commissures straight. Beak short, anteriorly excavated, submesothyridid to mesothyridid. Costae narrowly rounded, 20–25 in number, intercalations and bifurcations sporadic in three generations.

Ventral valve moderately convex in side view, with greatest convexity at umbo; anterior profile forming low dome with fairly steep sides. No sulcus evident. Umbonal and median regions moderately swollen.

Dorsal valve very gently convex in side view, forming broad, low dome with gently sloping sides in anterior profile. Median and umbonal regions moderately swollen. No fold or sulcus discernible.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380307	17.0	14.6	15.3	10.6	77
380308a	18.0	15.9	15.7	11.5	75
380309	18.0	15.9	16.8	10.9	83
380333a	18.2	16.0	15.8	11.3	73
380333b	15.7	14.0	14.8	9.6	82
380333c	15.0	13.2	12.6	9.4	71

OCCURRENCE.—Dhruma Formation (*Ermoceras* Zone): S1167; (*Thambites* Zone): S1001, S1036, S1046, S1157, S1160, S1440, S1501, S1503, KK8-17.5, -20.5, -23, -27.7, -30–35, 30–38, -32, -33–35, -33.5, -35–38, -37, KK8a-27; (*Tulites* Zone): S1747; KK8a-27, KK8a-34; (*Micromphalites* Zone): KK9-30–40. (*Dhrumaites* Zone): KK9-95, -95–96, -98; (Atash Member): KK9-112. (Upper Atash—Lower Hisyan members): S1462; (Zone not placed): S1156.

TYPES.—Hypotypes: USNM 380307, 380308a–d, 380309, 380314, 380333a-c, 380455a,b.

DISCUSSION.—This species is unusual in its numerous closely crowded costae without formation of a more or less distinct fold and sulcus. It is smaller and narrower than *S. costellata*, new species. Its ribbing is similar to that of *S. expansa*, new species, which is more widely ovate and has less convex valves and a well-defined sulcus on the ventral valve.

The identification of this species is based on comparison with Douvillé's figures (1916, pl. 7: figs. 13–15), which Farag (1960:67) put in the synonomy of *E. magharensis*. Farag's figures of his species are of an imperfect specimen somewhat larger than most of the Saudi Arabian specimens of this species.

Sphriganaria magnicostata, new species

PLATE 36: FIGURES 18–22

DIAGNOSIS.—Large strongly paucicostate *Sphriganaria*.

DESCRIPTION.—Large, roundly oval, ventral valve deeper than dorsal valve; maximum width at midvalve. Sides and anterior rounded; apical angle obtuse. Beak low, wide, anterior excavate. Foramen medium, mesothyridid. Costae strong, widely separated, narrowly rounded, about 11. Intercalations occasional.

Ventral valve fairly strongly convex in side view, broadly domed with narrow, steep sides in anterior profile. Umbonal and median regions strongly swollen. Fold formed by 2 strong costae at beak, expanding anteriorly to embrace 1 to 4 costae depending on number of intercalations.

Dorsal valve moderately convex in lateral view, forming broad, low dome in anterior view. Fold formed of prominent group of 5 or 6 costae at anterior.

MEASUREMENTS (in mm).—USNM 380334a: length 22.5, dorsal valve length 20.3, width 21.0, thickness 15.5, apical angle 107°.

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): S1747.

TYPES.—Holotype: USNM 380334a. Paratype: USNM 380334b.

DISCUSSION.—This species most nearly resembles *S. bramkampi*, new species, in its strong costation. It differs in having more circular valves, plumper dorsal valve, and fewer costae. It differs from *S. angulocostata*, new species, in its smaller size, rounder outline, and more rounded costae.

Sphriganaria modesta, new species

FIGURE 47; PLATE 36: FIGURES 23–27

DIAGNOSIS.—Narrowly ovate *Sphriganaria* with strong costae with few, scattered intercalations.

DESCRIPTION.—Medium, elongate oval, ventral valve deeper than dorsal valve, maximum width anterior to midvalve. Sides rounded, anterior margin narrowly truncated; apical angle acute. Commissures straight. Beak short, narrow, anteriorly excavate in some specimens. Foramen large, mesothyridid. Costae subangular, strong, with scattered insertions and bifurcations; costae numbering 15–20.

Ventral valve gently convex in side view, broadly domed with short steep flanks in anterior profile. Median 3 to 4 costae forming indistinct fold. This with median elevation on dorsal valve forms flattened anterior.

Dorsal valve flatly convex in side view, forming flattened dome with short steep sides in anterior view. Fold of 2 or 3 costae slightly elevated, indistinct.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380318a	21.0	18.3	17.7	14.0	74
380318b	20.0	17.3	16.0	12.6	75
380318c	20.8	18.3	17.5	12.8	77

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1001, S1502, S1503, S1505; KK8-22, -22.5; (*Tulites* Zone): S1486, S1488; (*Dhrumaites* Zone): S1436; KK9-97, -98. Upper Dhruma Formation (Zone not placed): S1295.

TYPES.—Holotype: USNM 380318a. Paratypes: USNM 380318b,c, 402738.

DISCUSSION.—This species resembles *S. capax*, new species, differing in its narrower triangular outline and details of the costation.

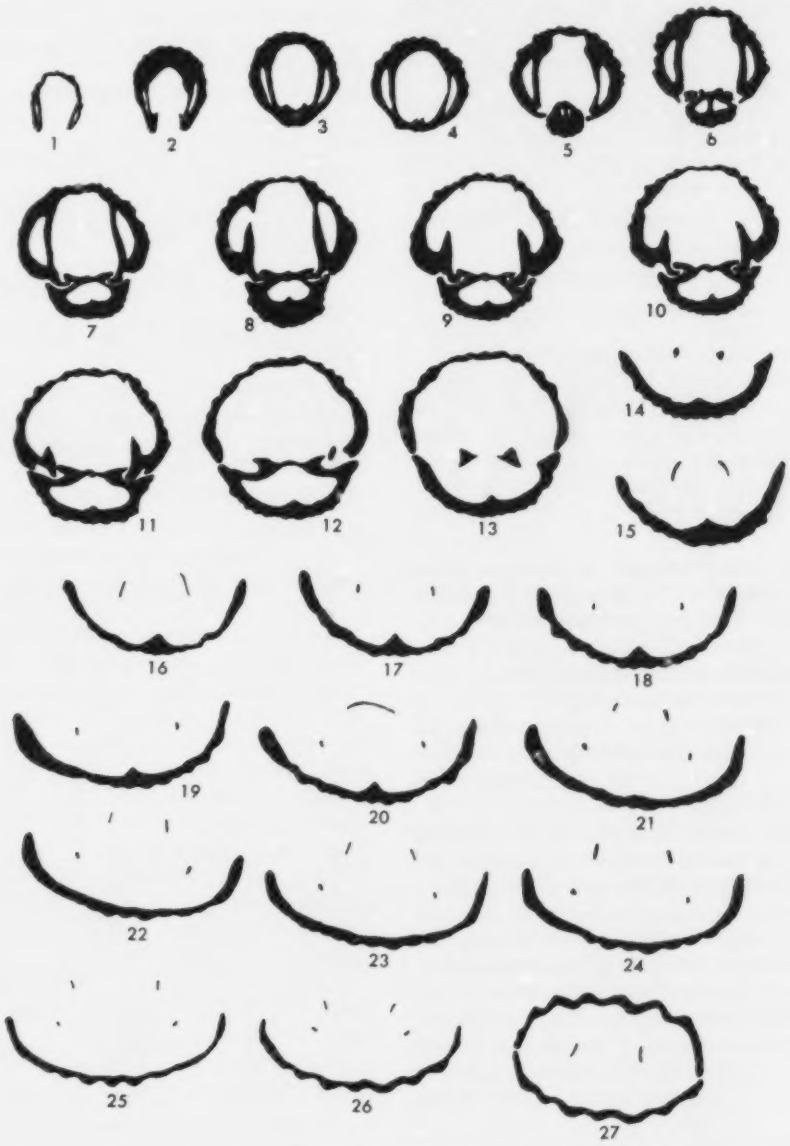

FIGURE 47.—*Sphriganaria modesta*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.6(0.6); 2, 0.9(1.5); 3, 0.7(2.2); 4, 0.3(2.5), 5, 0.6(3.1); 6, 0.2(3.3); 7, 0.6(3.9); 8, 0.3(4.2); 9, 0.4(4.6); 10, 0.4(5.0); 11, 0.3(5.3); 12, 0.4(5.7); 13, 0.4(6.1); 14; 0.3(6.4); 15, 0.6(7.0); 16; 0.5(7.5); 17; 0.4(7.9); 18, 0.9(8.8); 19, 1.0(9.8); 20, 0.1(9.9); 21, 0.5(10.4); 22, 0.5(10.9); 23, 0.5(11.4); 24, 0.8 (12.2); 25, 2.0(14.2); 26, 2.0(16.2); 27, 0.8(17.0). Approximately ×2; length 20.8 mm; USNM 402738; Locality S1295.

Sphriganaria nasuta, new species

PLATE 36: FIGURES 1–5

DIAGNOSIS.—Medium-size *Sphriganaria* with strong costae and well-marked nasute anterior.

DESCRIPTION.—Medium, elongate oval, maximum width at midvalve. Sides rounded, anterior margin protuberant; apical angle acute. Commissures straight. Beak low, narrow, anteriorly excavated. Foramen large, mesothyridid. Costae strong, subangular, bifurcations and intercalations, umbonal, median and marginal; costae numbering 18.

Ventral valve gently convex in lateral view, broadly, moderately domed with rounded lateral slopes in anterior view. Median and umbonal regions swollen. Fold low consisting of 4 costae at midvalve, increased to 7 at anterior.

Dorsal valve gently convex in side view, broadly domed with gentle slopes in anterior profile. Umbonal and median regions swollen. Four costae at midvalve forming low fold which is protuberant to form nasute anterior with ventral fold.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380337	20.3	18.0	16.7	12.4	79
380625	19.5	17.2	16.3	12.3	73

OCCURRENCE.—Dhruma Formation (*Thambites* Zone): S1501, S1620; (Zone not placed): S1156.

TYPES.—Holotype: USNM 380337. Paratype: USNM 380625.

DISCUSSION.—Narrowly oval form and narrowly rounded nasute anterior separate this species from *S. elliptica*, new species. *Sphriganaria eximia*, new species, is nasute but it is much larger, differently shaped, and with more numerous costae.

Sphriganaria obesa, new species

PLATE 36: FIGURES 28–32

DIAGNOSIS.—narrowly elliptical *Sphriganaria* with much swollen dorsal valve.

DESCRIPTION.—Small, narrowly, longitudinally elliptical. Ventral valve deeper than dorsal valve; maximum width at anterior. anterolateral extremities rounded; anterior margin truncated; apical angle acute. Beak short, low, truncated; foramen large, permesothyridid. Costae narrowly rounded, separated by spaces narrower than costae, about 24 costae.

Ventral valve unevenly convex with posterior half moderately convex, anterior half flattened in side view. Anterior view narrowly domed with long steep sides. Posterior half swollen. Two costae stronger than others bound 3 costae slightly depressed below bounding 2 to form indistinct fold.

Dorsal valve unevenly convex in side view with posterior half convex, anterior half flattened. Anterior view forming narrow, high steep-sided dome, slightly higher than ventral valve in same view. Umbonal and median regions strongly swollen. Indistinct fold of 2 strong costae bounding 4 weaker ones.

MEASUREMENTS (in mm).—USNM 380364: length 18.4, dorsal valve length 16.5, width 14.4, thickness 13.3, apical angle 62°.

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): KK9-30–40.

TYPE.—Holotype: USNM 380364.

DISCUSSION.—This species is most like *S. elliptica*, new species. It differs from it in being more finely costate and in having both valves strongly swollen in the umbonal regions. If differs from *S. distincta*, new species, in its finer costation and more swollen valves.

Sphriganaria parva, new species

PLATE 36: FIGURES 6–17

DIAGNOSIS.—Small strongly costate *Sphriganaria*.

DESCRIPTION.—Small, elongate oval, maximum width at midvalve, ventral valve more convex than dorsal valve; sides rounded, anterior narrowly rounded to somewhat nasute; apical angle acute. Commissures straight. Beak low, narrow, resting on dorsal umbo, anterior excavated. Foramen large, mesothyridid. Costae thick, rounded, 7 or 8 in number.

Ventral valve gently convex in side view, moderately convex with steep lateral slopes in anterior view. Two prominent costae at beak form low fold embracing 1 or 2 costae.

Dorsal valve flatly convex in side view and forming low dome in anterior profile. Umbo and median region swollen. Umbo with 1 costa bifurcating at about 1/3 valve length to form 2 elevated costae and narrow fold, meeting ventral median in slight protuberance.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380351a	13.3	11.4	11.0	7.8	68
380351b	13.2	10.5	11.3	7.5	68
380351c	12.3	10.5	11.3	7.5	72
380351d	12.4	10.7	9.7	7.1	67

OCCURRENCE.—Middle Dhruma Formation (*Tulites* Zone): S1244.

TYPES.—Holotype: USNM 380351b. Paratypes: USNM 380351a, c–e.

DISCUSSION.—Small size and strong costation distinguish this species from most species described herein. It is smaller and differently costated than *S. distincta* and *S. angustata*, new

species both of which are small. It is wider and differently shaped than *S. distans*, new species.

Sphriganaria perovalis, new species

PLATE 37: FIGURES 37–41

DIAGNOSIS.—flatly convex *Sphriganaria* with low rounded, even costae.

DESCRIPTION.—Medium, elongate oval. Maximum width anterior of midvalve. Ventral valve slightly more convex than dorsal valve. Sides and anterior margin rounded; apical angle acute. Commissures straight. Beak low, rounded, suberect; foramen large, permesothyridid. Costae narrowly rounded, low, separated by striae about equal to width of costae; costae numbering 18. Intercalations on umbones and near midvalve.

Ventral valve gently convex in side view, moderately domed in anterior view. Umbonal and median regions swollen. No distinct fold or sulcus developed.

Dorsal valve flatly convex in side view, forming flattened dome in anterior profile. Umbonal and median regions moderately swollen. No fold or sulcus discernible.

Interior: Dorsal valve with median septum extending beyond midvalve.

MEASUREMENTS (in mm).—USNM 380341: length 19.0, dorsal valve length 16.8, width 16.0, thickness 11.0, apical angle 73°.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): KK8-23; (*Micromphalites* Zone): KK9–KK9-72.

TYPE.—Holotype: USNM 380341.

DISCUSSION.—This species resembles *S. distincta* and *S. elliptica*, both new species, in its oval form. It is distinguished from both, however, by its more expanded anterior and more numerous, low even costae. It is distinguished from *S. costellata*, new species, by its smaller size, more compressed valves, and fewer costae.

Sphriganaria rara, new species

PLATE 37: FIGURES 59–64

DIAGNOSIS.—Circular *Sphriganaria* with strong costae and truncated beak.

DESCRIPTION.—Small, circular, maximum width at midvalve; ventral valve deeper than dorsal valve. Apical angle obtuse. Commissures straight. Beak low, truncated, barely visible in dorsal view. Deltidial plates disjunct. Foramen large, permesothyridid. Costae strong, narrowly rounded; intercalations numerous, on umbo and anteriorly; 15 costae.

Ventral valve gently, evenly convex in side view, broadly, moderately domed in anterior view. Median region swollen. Two major costae in midvalve bound slightly depressed area of 3 costae forming poorly defined fold.

Dorsal valve flatly convex in side view, flatly domed in anterior profile. Umbonal and median regions gently swollen. Fold, poorly defined, formed by 2 strong costae.

MEASUREMENTS (in mm).—USNM 380339: length 14.8, dorsal valve length 13.7, width 15.5, thickness 10.0, apical angle 112°.

OCCURRENCE.—Lower Dhruma Formation (*Dorsetensia* Zone): KK7-10.5.

TYPE.—Holotype: USNM 380339.

DISCUSSION.—This species is most like *E. intercalata*, new species, which is also circular and with a low beak, differing in a still lower beak, stronger and less numerous costae, and greater apical angle. This species is unique in the collection.

Sphriganaria subcircularis, new species

PLATE 37: FIGURES 42–46

DIAGNOSIS.—Nearly circular *Sphriganaria* with narrow protuberant beak.

DESCRIPTION.—Medium, subcircular, maximum width at midvalve. Apical angle near 90°. Beak short, narrow; foramen large, permesothyridid. Costae rounded with insertions on umbones only; costae number about 20.

Ventral valve gently convex in side view, broadly, gently domed in anterior view. Umbonal and median regions swollen. No fold or sulcus.

Dorsal valve flatly convex in lateral view, forming broad, low dome with gentle lateral slopes in anterior view. No fold.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees.

USNM	*Length*	*Dorsal valve length*	*Width*	*Thickness*	*Apical angle*
380315	19.8	17.8	19.2	12.4	90
380342	18.3	16.8	18.0	11.4	91

OCCURRENCE.—Dhruma Formation (*Dorsetensia* Zone): KK7-96; (*Thambites* Zone): KK8-33.5.

TYPES.—Holotype: USNM 380315. Paratype: USNM 380342.

DISCUSSION.—This species differs from *S. intercalata* and *S. rara*, new species, both circular forms, in different costation pattern, larger size, and longer beak.

Sphriganaria varicostata, new species

PLATE 37: FIGURES 52–58

DIAGNOSIS.—Elongate oval *Sphriganaria* with strongly convex valves covered by narrowly rounded costae covered by fine zigzag lines.

DESCRIPTION.—Large, oval, ventral valve more convex than dorsal valve; sides broadly rounded; anterior narrowly rounded; apical angle acute. Commissures straight. Beak low, incurved, anteriorly excavated. Foramen large, permesothyridid. Costae narrowly rounded, in three generations; interspaces narrower than costae; numerous zigzag concentric lines.

Costae numbering about 28 including marginal intercalations.

Ventral valve strongly convex in side view, narrowly domed with steep sides in anterior profile. Umbonal and median regions swollen. Median bundle of about 7 costae slightly elevated forming obscure fold at anterior.

Dorsal valve evenly, moderately convex in side view, strongly domed with steep sides in anterior view. Median bundle of costae forming indistinct fold.

Interior: Ventral valve with thickened delthyrial cavity, short dental plates. Dorsal valve with thin socket ridges; hinge plate medially arched; median septum extending to about midvalve.

MEASUREMENTS (in mm).—USNM 380345: length 22.3, dorsal valve length 18.7, width 17.8, thickness 15.4, apical angle 78°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1170.

TYPE.—Holotype: USNM 380345.

DISCUSSION.—The only species like this one is *S. eximia*, new species, from the same zone. The two differ in ornament, *S. eximia* lacking the concentric lines, having less deep valves and in having its maximum width at midvalve rather than posterior to midvalve like *S. eximia*.

Sphriganaria species 1

PLATE 37: FIGURES 47–51

DESCRIPTION.—A poorly preserved specimen is noteworthy for its strongly incurved beak, unlike the beak of any other species described herein. Most *Sphriganaria* have suberect or straight beaks, or occasionally, as in *S. intercalata* and *rara*, new species, the beak is strongly truncated obliquely.

The specimen under consideration is about medium size for the genus with ventral valve fairly strongly convex and the dorsal valve gently convex. Costae are numerous with intercalations and bifurcations, about 15 on the margin.

MEASUREMENTS (in mm).—USNM 380505: length 17.8, dorsal valve length 14.5, width 16.0, thickness 11.2, apical angle 68°.

OCCURRENCE.—Lower Dhruma Formation (*Ermoceras* Zone): S1619.

SPECIMEN EXAMINED.— USNM 380505.

Sphriganaria species 2

PLATE 18: FIGURES 8–10

DESCRIPTION.—A single laterally squeezed specimen was taken from the Hanifa Formation, perhaps the youngest known specimen of *Sphriganaria*. The specimen resembles *S. magharensis* (Farag), new combination, which is the longest lived species found in Saudi Arabia. It differs in being thicker but this could be caused by the lateral squeezing it has undergone.

MEASUREMENTS (in mm).—USNM 380640: length 19, dorsal valve length 16.3, width 16.0?, thickness 14.4.

OCCURRENCE.—Hanifa Formation: S149.

SPECIMEN EXAMINED.—USNM 380640.

Xenorina, new genus

DIAGNOSIS.—Large zeilleriid resembling *Eudesia* with a large lobate cardinal process.

DESCRIPTION.—Large, oval, with rounded sides, narrowly rounded anterior, with tendency to become nasute. Lateral commissure straight; anterior commissure straight. Beak erect to incurved; foramen from moderately large to very small; mesothyridid. Costate, with costae implanted and intercalated especially on the umbones.

Interior: Ventral valve with pedicle collar and stout fairly long dental plates. Dorsal valve with short thick median septum, narrow hinge plate with long, bilobed cardinal process.

SPECIMENS EXAMINED.—66.

OCCURRENCE.—Bathonian to Callovian.

ETYMOLOGY.—Greek *xenos* (stranger), in allusion to its possession of the unusual cardinal process.

DISCUSSION.—Although the exterior of *Xenorina* resembles that of *Eudesia cardium* (Valenciennes, 1819) it differs in strong incurvature of the beak with its consequent diminution of the foramen. In comparison of the serial sections of *Xenorina* and *Eudesia cardium* (Valenciennes, 1819) (Figure 39), the latter is seen to have an elaborate cardinal process, not a massive bilobed structure like that of *Xenorina*. *Xenorina* appears to be confined to the upper part of the column from the *Micromphalites* Zone into the Tuwaiq Mountain Formation.

Xenorina ovata, new species

FIGURE 48; PLATE 36: FIGURES 33–57

DIAGNOSIS.—Large, abberrant, eudesiioid with swollen valves, numerous costae, strongly incurved beak with small foramen.

DESCRIPTION.—Large, elongate oval, ventral valve deeper than dorsal valve. Maximum width near midvalve. Sides rounded, anterior with suggestion of truncation or slight nasute protuberance. Apical angle acute. Commissures straight. Beak short, strongly incurved. Foramen ranging from medium to very small, mesothyridid. Costae numerous, with bifurcation on umbones, about 28 costae in adult. Implantation sporadic, best seen on umbones.

Ventral valve fairly strongly convex in side view, moderately domed with steep sides in anterior profile. Entire valve swollen. Indistinct fold of 4 to 8 costae extending along median region.

Dorsal valve moderately to strongly convex in side view. Anterior profile forming low dome with moderately steep

slopes. Indistinct fold corresponding to that of ventral valve forming slight truncation at anterior, or slight nasute anterior in old specimens.

Interior: Ventral valve with thick dental plates, thick cyrtomatodont teeth and pedicle collar. All structures thickened and covered by adventitious shell. Dorsal valve with prominent protuberant bilobed cardinal process; short thick, undivided hinge plates; thick short median septum scarcely meeting hinge plate. Loop with broad transverse band. Much interior thickening of structures in old specimens.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement from imperfect specimen.

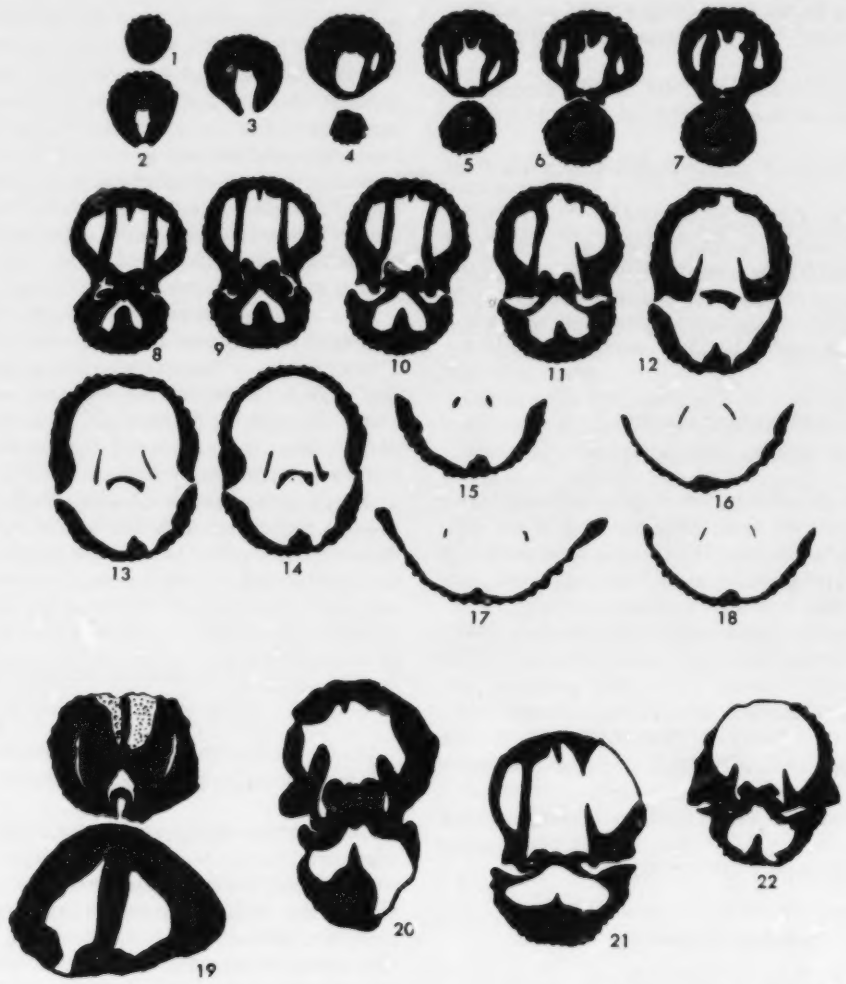

FIGURE 48.—*Xenorina ovata*, new species (numbers show distance in mm between sections and (in parentheses) distance from beak): 1, 0.4(0.4); 2, 0.9(1.3); 3, 0.4(1.7); 4, 0.6(2.3); 5, 0.4(2.7); 6, 0.4(3.1); 7, 0.1(3.2); 8, 0.4(3.6); 9, 0.4(4.0); 10, 0.4(4.4); 11, 0.2(4.6); 12, 0.5(5.1); 13, 0.3(5.4); 14, 0.1(5.5); 15, 0.2(5.7); 16, 0.8(6.5); 17, 0.7(7.2), 18, 0.4(7.6); approximately ×2; length uncertain, anterior imperfect, USNM 380664. 19, Section showing pedicle collar, approximately ×3, USNM 380193h; 20, specimen somewhat laterally compressed showing thick shell, ×2, USNM 380193g; 21, specimen showing early stage of cardinal process, ×2, USNM 380193d; all Locality S1460. 22, Section of specimen showing well-developed cardinal process, ×2; USNM 380641; Locality S1730.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle
380193a	30.0	27.0	23.6	23.4	75
380193b	23.5	21.5	20.7	17.0	75
380303a	21.7	19.0	17.3	13.0	68
380303b	19.7	17.0	15.8	12.4	62
380368	29.8	25.2	21.0	24.3	68
380376	30.6	27.0	25.0	20.0?	74
380555	29.0	25.6	25.0	21.0	79

OCCURRENCE.—Middle Dhruma Formation (*Micromphalites* Zone): S743; (*Dhrumaites* Zone): S1436. Upper Dhruma Formation (Atash Member): S1010, S1478, S1730. KK9 -112, -113; (Hisyan Member): S1444, S1676; (Zone not placed): S1180, S1235, S1469, S1471, S1742. Tuwaiq Mountain Formation: S1253, S1460, S1476.

TYPES.—Holotype: USNM 380193a. Paratypes: USNM 380193b–h, 380303a,b, 380367, 380368, 380376, 380555, 380641, 380643, 380664.

DISCUSSION.—This species is unusual for the strong incurvature of the beak and its foramen, which decreases in size in some specimens almost to a pinhole. It is a question whether or not there was a functional pedicle in those specimens with aborting pedicle opening. The thickened posterior of the pedicle valve would have permitted such shells to maintain a feeding position on the sea floor.

This is the largest zeilleriid in Saudi Arabia and might easily be confused with *Eudesia cardium* (Valenciennes, 1819) by its size and shape. *Eudesia cardium* is confined to the Bathonian in England and Europe. *Xenorina* is more finely costate than *E. cardium* and has a tiny foramen and strongly incurved beak, which is a rarity in the Eudesiidae. This species is exceptional for the development of a large cardinal process in the dorsal valve, similar to that developed in the large rhynchonellid *Heteromychus*, new genus, which also occurs in the Upper Dhruma Formation.

Family ZEILLERIIDAE Allan, 1940

Flabellothyris E. Eudes-Deslongchamps, 1884

Flabellothyris flabella (Defrance)

PLATE 32: FIGURES 18–25

Terebratula flabellum Defrance, 1827 [1828]:160.
Flabellothyris flabella.—E. Eude-Deslongchamps, 1884:262.

DESCRIPTION.—A single specimen, large for the genus, was taken at locality S1001 near the middle of the Dhruma Formation (*Thambites* Zone). The specimen is subtriangular, with length and width nearly equal. The dorsal fold occupies about a third of the valve width and is well elevated and formed by 3 costae. The sulcus is deep and occupied by 2 costae. The flanks are marked by 4 costae. The ventral beak is short with a large foramen margined by flaring deltidial plates.

MEASUREMENTS (in mm).—USNM 380306: length 12.3, dorsal valve length 10.3, width 13.7, thickness 10.3.

OCCURRENCE.—Middle Dhruma Formation (*Thambites* Zone): S1001.

TYPE.—Hypotype: USNM 380306.

Mycerosia, new genus

TYPE SPECIES.—*Mycerosia amygdaliformis*, new species.

DIAGNOSIS.—small, amygdaloidal Zeilleriacea with strong median septum supporting hinge plate.

SPECIMENS STUDIED.—about 200.

GEOLOGIC OCCURRENCE.—Callovian to Kimmeridgian.

ETYMOLOGY.—Greek *mykeros* (almond).

DESCRIPTION.—Small, amygdaloidal, pentagonal, maximum width in posterior third; ventral valve moderately convex, dorsal valve flatly convex. Anterior somewhat tapered. Anterior commissure rectimarginate with slight tendency toward uniplication. Lateral commissure straight. Beak small, erect; foramen medium, mesothyridid. Surface smooth.

Ventral valve with short pedicle collar, short dental plates supporting small teeth. Muscle scars not seen.

Dorsal valve interior with strong socket ridges; hinge plate flat or slightly arched dorsally, with or without low median elevation. Dorsal median septum thin, high, completely supporting hinge plate. Loop long, anteriorly fringed. Crura short, crural processes narrowly pointed.

DISCUSSION.—This genus is externally similar to *Gusarella* Prosorovskaya (1962) but differs in having a strong median septum, a structure lacking in *Gusarella*. There is some external resemblance to *Zeillerina* Kyansep, 1959. In that genus, however, there is a pedicle collar and cardinal process, and the septum supports the hinge plate only at the very apex.

Mycerosia amygdaliformis, new species

PLATE 32: FIGURES 6–17

Zeilleria latifrons.—Muir-Wood, 1935:143 [not *Zeilleria latifrons* Krumbeck, 1905].

DIAGNOSIS.—Small, anteriorly tapered zeilleriids.

DESCRIPTION.—Small, almond-shaped, maximum width posterior of midvalve. Sides broadly rounded forming shoulders a little posterior of midvalve; anterior margin narrowly rounded; apical angle obtuse. Ventral valve deeper than dorsal valve. Lateral commissure straight; anterior commissure rectimarginate. Beak low, broad, suberect, submesothyridid to mesothyridid, telate. Foramen small. Surface with concentric growth lines only.

Ventral valve moderately convex in side view, forming moderately high, steep-sided dome in anterior view. Median region swollen; anterior third flattened.

Dorsal valve flatly convex in side view, forming low dome in anterior profile. Umbonal and median regions swollen.

Anterior slightly flattened.

Interior: Ventral valve with small cyrtomatodont teeth supported by short dental plates. No other details. Dorsal valve with concave hinge plate supported by short, thin septum extending for about 1/3 valve length, crura short. Crural processes short, sharply pointed. Loop long extending for about 4/5 valve length. Descending lamellae reaching about 2/3 loop length; transverse band narrow laterally, wide ventrodorsally with short projections extending dorsally from junction with descending lamellae. Ascending and descending branches of loop spinose.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmarks indicate measurement not possible from imperfect specimen and estimated measurement, respectively.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle
380244a	16.6	14.7	13.5	9.5	91
380244b	16.8	14.6	13.2	9.4	98
380244c	16.4	14.6	12.6	9.4	92
380244d	12.8	11.5	11.6	6.8	102
380245a	14.7	13.2	12.2	8.2	98
380245b	15.1	13.2	11.8	8.8	98
380245c	14.0	12.3	11.5	8.2	98
380245d	20.0	17.2	15.8	?	102
380626a	18.8	16.5	14.6?	10.0	96
380626b	16.5	14.7	13.0	9.2	95
380626c	17.3	15.0	13.2	9.0	88

OCCURRENCE.—Tuwaiq Mountain Formation: S459. Hanifa Formation: S1050, KK10-01, -25, -25.5, -26, -26.5, -34.5, -37.5.

TYPES.—Holotype: USNM 380245c. Paratypes: USNM 380244a–d, 380245a,b,d,e, 380302a–c, 380626a–e.

DISCUSSION.—Specimens referred by Muir-Wood (1935:143, pl. 10: figs. 3a-c) to *Zeilleria latifrons* Krumbeck, 1905, strongly resemble *M. amygdaliformis* but are slightly smaller than the Saudi Arabian species. They have the same amygdaloidal form. Compared to *Z. latifrons* Krumbeck the Saudi Arabian specimens are much larger and do not have the rounded form of Krumbeck's (1905, pl. 9: fig. 20a–c) specimen chosen by Muir-Wood as type of the species.

Weir (1938:40, pl. 3: figs. 3a,b, 4) figured specimens as *Zeilleria subbucculenta* (Douvillé, 1916:37, pl. 1: fig. 24) that resemble *M. amygdaliformis*; they are, however, larger and rounder than the Saudi Arabian forms. Weir's specimens are said to come from the Kambe Limestone (Upper Bajocian of Kenya) a stratigraphic level considerably below that of the Hanifa Formation. Douvillé's specimen is from the Bathonian(?) of Sinai Peninsula, Egypt. It is about the same size but rounder than the Saudi Arabian species.

Rugitela Muir-Wood, 1936

Rugitela primaria, new species

PLATE 32: FIGURES 26–35

DIAGNOSIS.—Small elongate *Rugitela*.

DESCRIPTION.—Medium, elongate oval, maximum width slightly anterior of midvalve. Ventral valve deeper than dorsal valve. Anterior margin nearly straight, sides gently rounded; apical angle acute. Lateral commissure straight; anterior commissure rectimarginate. Beak narrow, moderately protuberant, erect. Foramen fairly large, mesothyridid. Surface with concentric growth lines only.

Ventral valve strongly convex in side view, forming high narrow steep-sided dome in anterior profile. Umbonal and median regions strongly swollen. Anterior third somewhat flattened.

Dorsal valve moderately convex in side view, strongly domed in anterior profile, less so than ventral valve. Median region swollen with shallow, narrow umbonal sulcus extending for third to quarter of valve surface length; anterior slightly flattened.

Interior: Ventral valve with long dental plates and short median myophragm between dental plates. Dorsal valve median septum extending anteriorly one-third valve surface length.

MEASUREMENTS.—All measurements are in millimeters, except apical angles, which are in degrees; questionmark indicates estimated measurement from imperfect specimen.

USNM	Length	Dorsal valve length	Width	Thickness	Apical angle
380211a	19.4	16.3	14.2	13.8	65
380211b	18.4	14.8	15.7	15.4	68
380515a	18.5	15.7	15.4	12.8?	77

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S989, S1031, S1034.

TYPES.—Holotype: USNM 380211a. Paratypes: USNM 380211b, 380515a,b.

DISCUSSION.—This species is similar to *Zeilleria radstockiensis* Davidson (see Muir-Wood, 1936) from Lower Lias of England. It differs in having longer beak and a more swollen dorsal valve.

The four specimens of smooth, swollen zeilleriids from the Marrat Formation are here placed in *Rugitela* although they are earlier in appearance than most species of the genus which are mainly Bathonian in age. The Marrat (late Lias) specimens in shape are like the type species as figured by Muir-Wood (1936, pl. 2: fig. 13a,b). They are also umbonally sulcate, a requisite for the genus mentioned by Muir-Wood in her description.

There are also traces of concentric rugae. A feature not mentioned in her description or seen in her serial sections is the short myophragm between the dental plates.

Zeilleria Bayle, 1878

Zeilleria species 1

PLATE 32: FIGURES 1–5

DESCRIPTION.—Small, elongate oval, inequivalve, ventral valve strongly convex, dorsal valve nearly flat. Sides and anterior rounded; apical angle acute. Anterior commissure rectimarginate. Beak low, rounded, incurved. Foramen small, mesothyridid; deltidial plates conjunct. Surface with concentric growth lines only. Dorsal valve septum slightly more than a third valve surface length.

MEASUREMENTS (in mm).—USNM 380358: length 8.8, dorsal valve length 6.9, width 7.4, thickness 5.4, apical angle 81°.

OCCURRENCE.—Tuwaiq Mountain Formation: S154.

SPECIMEN EXAMINED.—USNM 380358.

Zeilleria species 2

PLATE 18: FIGURE 7

DESCRIPTION.—A single much decorticated specimen, elongate oval in outline, narrowly compressed lateral view, and having a long median septum. The specimen is mentioned as indicating another zeilleriid in the Marrat Formation.

OCCURRENCE.—Marrat Formation (*Bouleiceras* Zone): S1175.

SPECIMEN EXAMINED.—USNM 380562.

Appendix I

Station Numbers by Formation and Zone

MARRAT FORMATION

Bouleiceras Zone: S989, S990, S1030, S1031, S1034, S1175; KK6-14.

Nejdia Zone: S1628.

DHRUMA FORMATION

Zone not placed: S457, S1004, S1118, S1119, S1120, S1156, S1158, S1179, S1250, S1258, S1274, S1285, S1414, S1418, S1447, S1448, S1449, S1450, S1456, S1457, S1468, S1612, S1644, S1652, S1687, S1688, S1743, S1755, S1786, S1788, S1789, S1790; Astro 61.

Lower Dhruma Formation

Dorsetensia Zone: S1787, KK6, KK7–KK7-96.

Between *Dorsetensia* and *Ermoceras* Zones: S996, S1057, S1202.

Ermoceras Zone: S997, S1056, S1162, S1164, S1166, S1167, S1170, S1409, S1485, S1506, S1617, S1618, S1619, S1661, S1677, S1679, S1695; KK7-130.5–KK7-133, KK8–KK8-5.5.

Middle Dhruma Formation

Thambites Zone: S1001, S1036, S1044, S1045, S1046, S1157, S1160, S1440, S1482, S1501, S1502, S1503, S1505, S1596, S1620; KK7-134–KK7-138, KK8-6–KK8-38.

Tulites Zone: S1191, S1244, S1283, S1305, S1422, S1486, S1488, S1621, S1629, S1684, S1738, S1747; KK8-39–KK8A-58.

Micromphalites Zone: S743, S1150, S1151, S1424, S1496, S1498, S1500; KK9-9–KK9-72.

Dhrumaites Zone: S1005, S1006, S1007, S1009, S1200, S1275, S1425, S1436, S1508, S1685, S1765; KK9-73–KK9-111.

Upper Dhruma Formation

Atash Member: S1010, S1148, S1296, S1478, S1730; KK9-112-KK9-123.

Hisyan Member: S1237, S1444, S1445, S1453, S1463, S1615, S1676, S1724.

Upper Atash—Lower Hisyan members: S1462.

Zone not placed: S736, S1180, S1235, S1249, S1251, S1252, S1257, S1295, S1311, S1469, S1471, S1613, S1742.

TUWAIQ MOUNTAIN FORMATION: L916[= S154], S293, S295, S296, S459, S800, S1146, S1198, S1199, S1253, S1309, S1365, S1446, S1458, S1460, S1467, S1476, S1674, S1675, S1702, S1712, S1715, S1784.

HANIFA FORMATION: S149, S625, S776, S1048, S1050, S1052, S1053, S1298, S1299, S1443, S1682; KK10-0–KK10-38.

Appendix II

Localities with Faunal Lists

Aramco L Series

The Aramco L series are from the same areas as the S series.

L916 [= S154]. Tuwaiq Mountain Formation (18 m above base of cliff), 26°21'32"N, 44°47'59.50"E, Wadi Aruma quadrangle.

Arabatia concava, new species
Bihenithyris? abnormis, new species
B. mediocostata, new species

Aramco S Series

The Aramco S series includes fossils collected by several geologists of the American-Arabian Oil Company (Aramco) between 1933 and 1952.

S149. Hanifa Formation?. Majma'a Area. At Camp Wadi Murrakh west of Jebel Umm er Ashash, Zilfi quadrangle.

Somalirhynchia arabica, new species
Sphriganaria species 2

S154. Tuwaiq Mountain Formation. 5 km northwest of Qhot on west front of Tuwaiq Mountains, Majma' Area, Jilfi quadrangle.

Apatecosia varians, new species
Arapsopleurum arabicum, new species
A. dubium, new species
A. rotundum, new species
Bihenithyris? abnormis, new species
B. mediocostata, new species
B. simulans, new species
Daghanirhynchia sulcata, new species
Dolichobrochus? ovatus new species
Gyrosina? ovata, new species
Pleuraloma abruptum, new species
P. convexum, new species
Somalirhynchia deficiens, new species
S. somalica (Dacqué)
Sphriganaria bramkampi, new species
Striithyris striata, new species
Tanyothyris angustata, new species
T. symmetrica, new species
Torquirhynchia? convexa, new species
Zeilleria species 1

S293. Tuwaiq Mountain Formation. Al'Ruma Area, 35 km S 35°W of Camp Ramaithan, from Tuwaiq Mountain escarpment near Zilfi, Zilfi Quadrangle.

Arabatia concava, new species
Kutchithyris? species 2
Pleuraloma? circulare, new species
Somalirhynchia somalica (Dacqué)

S295. Tuwaiq Mountain Formation. Ajibba Area, 4.3 km N 85°W of Ajibba, 27°24'24"N, 44°17'18"E, Aqibba quadrangle.

Somalirhynchia somalica (Dacqué)

S296. Tuwaiq Mountain Formation. Ajibba Area, 6 km N 88°W of Ajibba, Aqibba quadrangle.

Arabatia concava, new species
Dissoria tribulis, new species
Dolichobrochus? ovatus, new species
Pleuraloma anomalum, new species
P. labiatum, new species
Somalirhynchia deficiens, new species
S. somalica (Dacqué)
Striithyris saudiarabica, new species

S457. Dhruma Formation (Zone not placed). West side Tuwaiq Mountains, 5 km S 20°W of Hassaiyan Wells, Dhruma quadrangle.

Burmirhynchia decorticata, new species

S459. Tuwaiq Mountain Formation. West side Tuwaiq Mountain, 2 km southeast of Hassaiyan Wells, Dhruma quadrangle.

Apatecosia inornata, new species
Apothyris aberrans, new species
Daghanirhynchia sulcata, new species
Glyphisaria? divergens, new species
Mycerosia amygdaliformis, new species
Somalirhynchia deficiens, new species
S. somalica (Dacqué)

S625. Hanifa Formation (116–122 m below top). North wall of Sha'ib Ha, in measured section on north bank of Sha'ib Ha, 20.15 km S 23½°west of Riyadh water well number 1, 24.05 km west of Riyadh, 24°26.6'N, 46°37.3'E, Riyadh quadrangle.

Dorsoplicathyris? species
Somalirhynchia somalica (Dacqué)
Somalithyris ovata, new species

S736. Upper Dhruma Formation (Zone not placed). 1 km west of Khashm el Hassau, Dhruma quadrangle.

Arabicella subplana, new species
Arapsothyris magna, new species

S743. Middle Dhruma Formation (*Micromphalites* Zone). 1 km west of Khashm el Hassau, Dhruma quadrangle. (*Micromphalites* listed).

Arabicella subpentagonalis, new species
Arapsothyris magna, new species
Colpotoria plicatilis, new species
Daghanirhynchia angulocostata, new species
Sphriganaria curtirostra, new species
Xenorina ovata, new species

S776. Hanifa Formation (46–51 meters above base). Wadi Hamr, South Tuwaiq, 1.75 km N 86°30′W of Ain Ranqia. 22°22′N, 46°19′E, Hamr quadrangle.

Somalithyris rotundata, new species

S800. Tuwaiq Mountain Formation (62 m below top). Khashm el Amur, Wadi Duwasir, 20°24′54″N, 45°23′12″E, Dam quadrangle.

Daghanirhynchia sulcata, new species
Somalirhynchia somalica (Dacqué)

S989. Marrat Formation (*Bouleiceras* Zone, 14–16 m above base). Bukhara Area, 3.4 km S 67°W of Ain Bukhara, 1.6 km S 77° W of Bukhara Astro Station, 24°09′18″N, 45°09′24″E, Dhruma quadrangle.

Apothyris species
Calyptoria carinata, new species
Liospiriferina obesa, new species
Rugitela primaria, new species

S990. Marrat Formation (*Bouleiceras* Zone, 9–15 m above base of section) same measured section as S989 Bukhara Area, Dhruma Quadrangle.

Liospiriferina obesa, new species

S996. Lower Dhruma Formation (74–83 m above base between *Dorsetensia* and *Ermoceras* Zones). Bukhara Area, Dhruma quadrangle.

Baeorhynchia carinata, new species
B. nitida, new species

S997. Lower Dhruma Formation (*Ermoceras?* Zone, 83–94 m above base of Dhruma Formation). Bukhara Area, Dhruma quadrangle. ("*Micromphalites*" is listed in the records of the American-Arabian Oil Company in which the distance given from the base of the Dhruma Formation indicates placement in the *Ermoceras* Zone.)

Schizoria species 2 (exact position uncertain)

S1001. Middle Dhruma Formation (*Thambites* Zone). Mashraq Area. In measured section between Khashm Mashraq and a point 1.9 km S 25°W, Dhruma quadrangle.

Conarosia species
Eurysites rotundus, new species
E. transversus, new species
Flabellothyris flabella (Defrance)
Sphaeroidothyris arabica, new species
Sphriganaria costellata, new species
S. elliptica, new species
S. magharensis (Farag), new combination
S. modesta, new species

S1004. Dhruma Formation (Zone not placed). Same locality as S1001.

Daghanirhynchia angulocostata, new species

S1005. Middle Dhruma Formation (*Dhrumaites* Zone, 127–143 m below top of Dhruma Formation). Same locality as S1001.

Pycnoria magna, new species

S1006. Middle Dhruma Formation (*Dhrumaites* Zone, 119–126 m below top of Dhruma Formation). Same locality as S1001.

Kutchithyris? species 1

S1007. Middle Dhruma Formation (96–119 m below top = *Dhrumaites* Zone). Mashraq Area, same locality as S1001.

Arabicella subpentagonalis, new species
A. subplana, new species
Arapsothyris magna, new species
Daghanirhynchia angulocostata, new species
Pycnoria magna, new species
Sphriganaria angulocostata, new species

S1009. Middle Dhruma Formation (76–93 m below top = *Dhrumaites* Zone) Mashraq Area, same locality as S1001.

Arabicella ovalis, new species

S1010. Upper Dhruma Formation (0–75 m below top = Atash Member). Mashraq Area, between Khashm Mashraq and a point 1.9 km S 25°W, Dhruma quadrangle.

Xenorina ovata, new species

S1030. Marrat Formation (*Bouleiceras* Zone, 5.8–8 m above the base). Measured section in Jebel in front of escarpment 23.15 km S 02°E of the Bukhara Astro Station, 23°56′36″N, 46°11′00″E, Birk quadrangle.

Calyptoria extensa, new species
Spiriferina species 1, 2

S1031. Marrat Formation (*Bouleiceras* Zone, 8.2–10.2 m above base). Same locality as S1030.

Calyptoria carinata, new species
Rugitela primaria, new species

S1034. Marrat Formation (*Bouleiceras* Zone, 5.8–10.2 m above base, immediately below red shale unit). Around south base of isolated jebel, 24.8 km S 1°W of Ain Bukhara, 23°56′36″N, 46°11′00″E, Birk quadrangle. (*Bouleiceras* listed)

Calyptoria carinata, new species
C. extensa, new species
Liospiriferina obesa, new species
L. vulgata, new species
Rugitela primaria, new species

S1036. Middle Dhruma Formation (*Thambites* Zone, 21.1–31.6 m above top Dhibi Member), South side of Wadi Hauta, 67.5–71.5 km S 8°45′E to S 7.25° E of Bukhara Astro Station, 23°31′12″N, 46°16′24″E, Birk quadrangle.

Conarosia medialis, new species
C. rotundata, new species
Eurysites rotundus, new species
E. transversus, new species
Sphriganaria magharensis (Farag), new combination

S1044. Middle Dhruma Formation (*Thambites* Zone, 8.9 m above Dhibi Member). 10.2 km N 71°E of Bukhara Astro Station, 24°11.4′N, 46°17.1′E, Dhruma quadrangle.

Conarosia rotundata, new species
Sphaeroidothyris arabica, new species

S1045. Middle Dhruma Formation (*Thambites* Zone, 14.5–16.5 m above Dhibi Member). 8.4 km N 73.30°E of Ain Bukhara, 24°11.4′N, 46°16.1′E, Dhruma quadrangle. (*Thambites* listed)

Conarosia ovata, new species
C. sphenoidea, new species
Eurysites transversus, new species

S1046. Middle Dhruma Formation (*Thambites* Zone, 24.8 m above Dhibi Member). Same section as S1044. 24°11′18″N, 46°16′06″E, Dhruma quadrangle. (*Thambites* listed)

Conarosia concinna, new species
C. medialis, new species
C. ovata, new species
Eurysites rotundus, new species

Sphriganaria costellata, new species
S. magharensis (Farag), new combination

S1048. Hanifa Formation (Basal 19.4 m). Measured section on south side of Sha'ib Nisa, 10 km N 84°30'W of Jebel Umm Fardah (about 64.9 km roughly W of Jebel Firzon), 24°16'18"N, 46°37'23"E, Riyadh quadrangle.

Somalirhynchia africana Weir

S1050. Hanifa Formation (28.2–37.7 m above base). Same locality as S1048.

Dorsoplicathyris? species
Somalirhynchia arabica, new species
Mycerosia amygdaliformis, new species

S1052. Hanifa Formation (44.3–46.3 m above base). Same locality as S1048.

Dorsoplicathyris? species

S1053. Hanifa Formation (46.5–50 m above base). Same locality as S1048.

Somalithyris subcircularis, new species

S1056. Lower Dhruma Formation (*Ermoceras* Zone). At escarpment 4.5 km N 28°E of Bukhara Astro Station, Dhruma quadrangle.

Sphaeroidothyris arabica, new species
Sphriganaria angustata, new species

S1057. Lower Dhruma Formation (22.0–37.6 m below top of Dhibi Member = between *Dorsetensia* and *Ermoceras* zones). In measured section on north side of Wadi Birk, 14.2 km S 49°E of Khashm Birk (Dasman), Birk quadrangle.

Schizoria costellata, new species
S. secta, new species

S1118. Dhruma Formation (Zone not placed). From hill at station 533.62, 21°57'58"N, 45°55'08"E, Maqran aqadrangle.

Burmirhynchia rostrata, new species
Daghanirhynchia angulocostata, new species

S1119. Dhruma Formation (Zone not placed). At Station 915.7, 22°02' 16"N, 45°53'45"E, Hamr quadrangle.

Burmirhynchia rostrata, new species
Conarosia medialis, new species
C. ovata, new species
Daghanirhynchia angulocostata, new species
Sphriganaria costellata, new species

S1120. Dhruma Formation (Zone not placed). At station 939.8, 22°02'57"N, 45°56'58"E, Hamr quadrangle.

Daghanirhynchia angulocostata, new species

S1146. Tuwaiq Mountain Formation. Jebel Qaradan northwest end of Qaradan Graben, 24°43'38"N, 45°53'44"E, Dhruma quadrangle.

Arabicella? costata, new species
Arapsothyris magna, new species
Eurysites transversus, new species

S1148. Upper Dhruma Formation (probably Atash Member). 0.75 km S,70°W of Khashm Hassiya, Point 28, 24°50'27"N, 46°01'46"E, Dhruma quadrangle.

Arabicella subpentagonalis, new species
A. subplana, new species
Ectyphoria inflata, new species
Heteromychus magnificus, new species

S1150. Middle Dhruma Formation (*Micromphalites* Zone) Hassiyan Pass Area, 6.5 km S 70°W of Khashm Hassiya Station, 4222.0, 24°48'43"N, 46°58' 36"E, Dhruma quadrangle. (*Micromphalites* listed)

Arabicella subpentagonalis, new species
A. subplana, new species
Daghanirhynchia? triangulata, new species

S1151. Middle Dhruma Formation (*Micromphalites* Zone). Hassiyan Pass Area, 24°49'29"N, 46°58'14"E, Dhruma quadrangle.

Arabicella subpentagenalis, new species
Colpotoria plicatilis, new species

S1156. Dhruma Formation (Zone not placed). Section 13.5 km N 45°W of Dhruma Point 20, 24°42'14"N, 46°03'00"E, Dhruma quadrangle.

Avonothyris? species
Pionopleurum obesum, new species
Sphriganaria angustata, new species
S. costellata, new species
S. magharensis (Farag), new combination
S. nasuta, new species

S1157. Middle Dhruma Formation (*Thambites* Zone). Same locality as S1156.

Conarosia medialis, new species
C. ovata, new species
Eurysites rotundus, new species
E. transversus, new species
Sphriganaria costata, new species
S. magharensis (Farag), new combination

S1158. Dhruma Formation (Zone not placed). 8 km S 30°W from Hassiyan, 24°44'07"N, 46°01'20"E, Hassiyan Pass Area, Dhruma quadrangle.

Conarosia medialis, new species

S1160. Middle Dhruma Formation (*Thambites* Zone = 30–40 m above top of Dhibi Member). 3.5 km N 36°W of Dhruma, 24°38'12"N, 46°07'30"E. Dhruma quadrangle. (*Thambites* listed)

Conarosia concinna, new species
C. medialis, new species
C. ovata, new species
Eurysites rotundus, new species
Sphriganaria costellata, new species
S. lirata, new species
S. magharensis (Farag), new combination

S1162. Lower Dhruma Formation (*Ermoceras* Zone, about 25–27.5 m below top of Dhibi Member). 10.5 km N 53°W of north corner of Dhruma, 24°40' 06"N, 46°03'00"E, Dhruma quadrangle. (*Ermoceras* listed)

Sphriganaria eximia, new species

S1164. Lower Dhruma Formation (*Ermoceras* Zone = about 13 m below top of Dhibi Member). 10.5 km N 53°W of north corner of Dhruma, 24°40'06"N, 46°03'00"E, Dhruma quadrangle.

Terebratulacean genus and species undetermined 3

S1166. Lower Dhruma Formation (*Ermoceras* Zone). 7 km N 3°E (magnetic) of Khashm Mijhara, Station 3117.1, 24°38'27"N, 46°03'38"E, Dhruma quadrangle.

Sphaeroidothyris arabica, new species
Sphaeroidothyris species 1

S1167. Lower Dhruma Formation (*Ermoceras* Zone, 13–33 m below top of Dhibi Member). 90 km N 58.25°W of north corner of Dhruma, 24°39'18"N, 46° 03'18"E, Dhruma quadrangle. (*Ermoceras* listed)

Conarosia ovata, new species

Loboidothyris? species
Sphaeroidothyris species 1
Sphriganaria irregularis, new species
S. magharensis (Farag), new combination
Stiphrothyris? species 1
Strongyloria circularis, new species
Terebratulacean genus and species undetermined 2, 3

S1170. Lower Dhruma Formation (*Ermoceras* Zone, 13–27 m below top of Dhibi Member). 6 km S 6°W of Dhruma on south side of Dhruma Graben and north side of Khubra, 6.3 km S 2½°E of north corner of Dhruma, 24°40′06″N, 56°03′00″E, Dhruma quadrangle. (*Ermoceras* listed)

Sphriganaria varicostata, new species
Strongyloria circularis, new species

S1175. Marrat Formation (*Bouleiceras* Zone, base). Measured section at Khashm Duwaiban, Dhruma quadrangle.

Liospiriferina obesa, new species
Spiriferina species 3
Zeilleria species 2

S1179. Dhruma Formation (Zone not placed). 9 km west of Hassiyan Pass, Dhruma quadrangle.

Daghanirhynchia angulocostata, new species
Globirhynchia subtriangulata, new species
Pycnoria magna, new species

S1180. Upper Dhruma Formation (Zone not placed). Zib Hamyd, 12.5 km N 85°E of Dhruma, 24°37′24″N, 46°15′15″E, Dhruma quadrangle.

Xenorina ovata, new species

S1191. Middle Dhruma Formation (*Tulites* Zone, 20.7–21.7 m below the *Micromphalites* Zone). 8.4 km N 68°W of Juraifa, 7.3 km N 66.30°W of west edge of Juraifa Gardens, 24°33′35″N, 45°11′05″E to 25°33′30″N, 45°10′54″E, Shaqra quadrangle. (*Tulites?* listed)

Daghanrhynchia angulocostata, new species
Kallirhynchia arabica, new species
K. orbicularis, new species
Kutchirhynchia arabica, new species

S1198. Tuwaiq Mountain Formation. (16.6 m above base). Head of Wadi Abu "tsidadah," southwest corner of Khashm et Turab, 25°02′24″N, 45°53′06″E, Wadi Atj quadrangle.

Striithyris striata, new species

S1199. Tuwaiq Mountain Formation (43.4 m above base). Same locality as S1198.

Somalirhynchia deficiens, new species
S. somalica (Dacqué)
Striithyris striata, new species

S1200. Middle Dhruma Formation (55–85 m above base of *Micromphalites* fauna = *Dhrumaites* Zone). 3.3 km S 36°W of Khashm Balaidiya 24°51′10″N, to 24°54′08″N, 45°57′42″E to 45°38′00″E, Dhruma quadrangle.

Arabicella subplana, new species
Arapsothyris magna, new species
Colpotoria plicatilis, new species

S1202. Lower Dhruma Formation (52.7 m above Marrat-Dhruma contact = a point between the *Dorsetensia* and *Ermoceras* Zones). 3.5 km east of Jebel Abu Er Rakhaim, 15.6 km N 11°W of Ain Bukhara, 24°18′22″N to about 24°18′00″N, 46°09′24″E to 46°09′24″E, Dhruma quadrangle.

Schizoria elongata, new species

S1235. Upper Dhruma Formation (Zone not placed). 15 km N 52°30′E of El Quasab, 25°23′15″N, 45°37′30″E, Wadi Atj quadrangle.

Arapsothyris magna, new species
Sphriganaria bramkampi, new species
Xenorina ovata, new species

S1237. Upper Dhruma Formation (Hisyan Member). Qasab Area, 25°38′30″N, 45°14′00″E, Shaqra quadrangle.

Sphriganaria bramkampi, new species

S1244. Middle Dhruma Formation (*Tulites* Zone, 15.7–20.7 m below the *Micromphalites* Clay). 8.4 km N 68°W of Juraifa, 7.3 km N 66½°W of Juraifa Gardens, 25°33′35″N to 25°33′30″N, 45°10′54″E to 45°11′00″ E, Shaqra quadrangle. (Tulites listed)

Apothyris aberrans, new species
Burmirhynchia decorticata, new species
Globirhynchia concinna, new species
G. subtriangulata, new species
Sphriganaria parva, new species

S1249. Upper Dhruma Formation (Zone not placed). Northwest of the extreme northwest point of Jebel esh Shi'ib, Haddar embayment, on slope, 55.9 m below the Tuwaiq Mountain cliff, 22°02′05″N, 45°57′30″E, Hamr quadrangle.

Sphriganaria bramkampi, new species

S1250. Dhruma Formation (Zone not placed): 55.9 m below Tuwaiq Mountain Cliff, same locality as S1249. (*Ermoceras runcinatum* listed)

Echyrosia costata, new species

S1251. Upper Dhruma Formation (Zone not placed). Northwest of the extreme point of Jebel esh Shi'ib, Haddar embayment, 22°02′05″N, 45°57′30″E, Hamr quadrangle.

Daghanirhynchia angulocostata, new species
Sphriganaria bramkampi, new species

S1252. Upper Dhruma Formation (Zone not placed), 55.9 m below Tuwaiq Mountain Cliff, same locality as S1249.

Sphriganaria bramkampi, new species

S1253. Tuwaiq Mountain Formation. Same locality as S1249.

Arapsothyris angustata, new species
Eurysites rotundus, new species
Xenorina ovata, new species

S1257. Upper Dhruma Formation (Zone not placed). On southwest side of hills northwest of Jebel esh Shi 'ib, 22°02′17″N, 45°57′20″E, Hamr quadrangle.

Arapsothyris angustata, new species
Daghanirhynchia angulocostata, new species
D.? triangulata, new species
Eurysites rotundus, new species
E. transversus, new species

S1258. Dhruma Formation (Zone not placed). Same locality as S1257.

Burmirhynchia decorticata, new species
Globirhynchia subtriangulata, new species

S1274. Dhruma Formation (Zone not placed). Haddar Embayment, 9.2 km S 36°W of Khashm Esh Shi'ib, 21°43.95′N to 21°43.65′N, 45°40.6′E, to 45°40.11′E, Maqran quadrangle.

Daghanirhynchia angulocostata, new species
Sphriganaria costellata, new species

S1275. Middle Dhruma Formation (9–14 m above *Micromphalites* Zone = *Dhrumaites* Zone). 8.5 km S 28°W of Khashm Esh Shi 'ib, 21°58′N, 45°55′E, Maqran quadrangle.

Burmirhynchia decorticata, new species
Daghanirhynchia angulocostata, new species

S1283. Middle Dhruma Formation (*Tulites* Zone). 24°18′24″N, 46°07′30″E, quadrangle not given.

Sphriganaria distincta, new species

S1285. Dhruma Formation (Zone not placed). Rijmon 'B' 31, 10.4 km S 28 ½°W of Khashm Hassiya, Dhruma quadrangle.

Sphriganaria costata, new species

S1295. Upper Dhruma Formation (Zone not placed). 25°00′39″N, 45° 54′06″E, Wadi Atj quadrangle.

Arabicella subpentagonalis, new species
Sphriganaria bramkampi, new species
S. capax, new species
S. modesta, new species

S1296. Upper Dhruma Formation (Atash Member). 24°52′00″N, 46°01′06″E, Dhruma quadrangle.

Arabicella ovalis, new species
A. subpentagonalis, new species
A. subplana, new species
Heteromychus magnificus, new species

S1298. Hanifa Formation (10–50 m above base). Jebel Bakkain, 24°58′N, 46°13′E, Dhruma quadrangle.

Somalirhynchia arabica, new species
S. somalica (Dacqué)
Somalithyris ovata, new species

S1299. Hanifa Formation (50–53.5 m above base), Jebel Bakkain, Dhruma quadrangle.

Kutchithyris? species 1

S1305. Middle Dhruma Formation (*Tulites* Zone). At Khashm esh Shajara, 35 km southwest of Haddar, 21°46′40″N, 45°41′48″E, Maqran quadrangle.

Daghanirhynchia angulocostata, new species

S1309. Tuwaiq Mountain Formation. At Khashm esh Shajara, 35 km southwest of Haddar, Maqran quadrangle.

Striithyris costata, new species

S1311. Upper Dhruma Formation (Zone not placed). At Khashm U on N scarp east of Ju 'ailan el Aqra, 21°37′42″N, 45°38′30″E, Maqran quadrangle.

Daghanirhynchia angulocostata, new species
Sphriganaria bramkampi, new species

S1365. Tuwaiq Mountain Formation. At Khashm Faraid, Mundafan quadrangle.

Daghanirhynchia angulocostata, new species
Sphriganaria bramkampi, new species

S1409. Lower Dhruma Formation (*Ermoceras* Zone). 23°12′48″N, 46°25′48″E, Birk quadrangle. (*Ermoceras* and *Dorsetensia* listed)

Amydroptychus formosus, new species
Nastosia coangustata, new species
N.? convexa, new species
Schizoria costellata, new species
S. elongata, new species
S. intercalata, new species
Schizoria species 1

S1414. Dhruma Formation (Zone not placed). 600 m north of 313.4, Dhruma quadrangle.

Burmirhynchia subnasuta, new species
Globirhynchia concinna, new species

S1418. Dhruma Formation (Zone not placed). On low nose 24.3 km N 64°W of Khashm Hisan (east side Nefud Beladin), 25°11′N, 45°39′E, Wadi Atj quadrangle.

Conarosia angustata, new species

S1422. Middle Dhruma Formation (*Tulites* Zone). On west side of Nefud Beladin, 27.6 km N 59°W of southwest corner of Khashm Hisan 25°12′24″N, 45°38′12″E, Wadi Atj quadrangle.

Conarosia concinna, new species
Sphenorhynchia? angulata, new species

S1424. Middle Dhruma Formation (*Micromphalites* Zone). 24°19′24″N, 46°18′48″E, Dhruma quadrangle. (*Micromphalites* listed)

Globirhynchia subtriangulata, new species

S1425. Middle Dhruma Formation (*Dhrumaites* Zone). 24°19′24″N, 46°18′48″E, Dhruma quadrangle.

Burmirhynchia decorticata, new species
Globirhynchia subtriangulata, new species
Pycnoria magna, new species

S1436. Middle Dhruma Formation (*Dhrumaites* Zone). Dhruma quadrangle. No other information.

Arabicella ovata, new species
Conarosia medialis, new species
Ectyphoria inflata, new species
Pycnoria magna, new species
Sphriganaria modesta, new species
Xenorina ovata, new species

S1440. Middle Dhruma Formation (*Thambites* Zone). 25°04′06″N, 45°44′24″E, Wadi Atj quadrangle.

Eurysites rotundus, new species
E. transversus, new species
Globirhynchia subtriangulata, new species
Sphriganaria angustata, new species
S. costata, new species
S. distincta, new species
S. magharensis (Farag), new combination

S1443. Hanifa Formation. South of Jebel Bakkain, Dhruma quadrangle.

Habrobrochus amygdaioideus, new species
Somalirhynchia arabica, new species
Somalithyris triangulata, new species

S1444. Upper Dhruma Formation (30 m above *Dhrumaites* Zone = Hisyan Member). 25°55′12″N, 45°58′36″E, Dhruma quadrangle.

Daghanirhynchia? triangulata, new species
Pycnoria magna, new species
Sphriganaria expansa, new species
Xenorina ovata, new species

S1445. Upper Dhruma Formation (34 m below Tuwaiq Mountain-Dhruma contact = Hisyan Member). Jebel Balaidiyah, in outlier at Khashm

Balaidiyah, 24°50′30″N, 45°02′06″E, Dhruma quadrangle.

Daghanirhynchia angulocostata, new species
Somalirhynchia arabica, new species
Sphriganaria bramkampi, new species

S1446. Tuwaiq Mountain Formation. Jebel Balaidiyah, 24°55′12″N, 45°58′36″E, Dhruma quadrangle.

Pionopleurum obesum, new species

S1447. Dhruma Formation (Zone not placed). Low outlier of Dhruma shale on east side Beladin, 18.8 km S 78°E to south part of Khashm Hisan, 8.8 km S 2½°W to northwest end of Jebel el Uraidh, 25°07′00″N, 45°41′10″E, Wadi Atj quadrangle.

Conarosia concinna, new species
C. medialis, new species
Eurysites rotundus, new species
E. transversus, new species
Pionopleurum compactum, new species
P. obesum, new species
Sphriganaria capax, new species

S1448. Dhruma Formation (Zone not placed). East side of Beladin, 20.4 km to south point of Khashm Hisan, 12.3 km S 1°E to northwest end of Jebel el Uraidh. Sample taken 1 km N 12°W of Station, 25°08′55″N, 45°40′52″E, Wadi Atj quadrangle.

Burmirhynchia cuneata, new species

S1449. Dhruma Formation (Zone not placed). 6.5 km S 40°W of Jebel Fahdah, 17.6 km N 17°E to W Jebel Qumah, 25°14′22″N, 45°34″E, Wadi Atj quadrangle.

Globirhynchia concinna, new species
Pionopleurum obesum, new species
Sphriganaria angustata, new species
S. argula, new species
S. distincta, new species

S1450. Dhruma Formation (Zone not placed). Same locality as S1448.

Arabicella subpentagonalis, new species
Conarosia concinna, new species

S1453. Upper Dhruma Formation (From 65–15 m below base of Tuwaiq Mountain Limestone = Hisyan Member), Ancient ceremonial site in Wadi el Fau, 19°54′53″N, 45°16′55″E, Fau quadrangle.

Sphriganaria intercalata, new species

S1456. Dhruma Formation (Zone not placed). Dhruma quadrangle. No other information.

Conarosia concinna, new species
Pionopleurum obesum new species
Sphriganaria angustata, new species

S1457. Dhruma Formation (Zone not placed, Middle or Upper). Haisiyan Pass, Dhruma quadrangle.

Conarosia angustata, new species
C. concinna, new species
C. ovata, new species
Pionopleurum obesum, new species
Sphriganaria bicostata, new species

S1458. Tuwaiq Mountain Formation. Haisiyan Pass, 24°51′36″N, 46°07′12″E, Dhruma quadrangle.

Somalirhynchia arabica, new species
S. deficiens, new species
S. somalica (Dacqué)
Striithyris striata, new species

S1460. Tuwaiq Mountain Formation. Between Khashm 38 and Khashm Hisan, on southeast side of Wadi, 25°05′00″N, 45°53′36″E, Wadi Atj quadrangle.

Arapsothyris angustata, new species
Eurysites rotundus, new species
E. transversus, new species
Xenorina ovata, new species

S1462. Upper Dhruma Formation (18–28 m above *Dhrumaites* Zone = Upper Atash-Lower Hisyan Members). South side Khashm et Turab, 25°02′06″N, 45°53′36″E, Wadi Atj quadrangle.

Apothyris aberrans, new species
Somaliryncbia deficiens, new species
Sphriganaria magharensis (Farag), new combination

S1463. Upper Dhruma Formation (Hisyan Member). Khashm et Turab, same locality as S1462.

Daghanirhynchia angulocostata, new species
Sphriganaria capax, new species

S1467. Tuwaiq Mountain Formation. Northwest end of Barra Graben, Wadi Atj quadrangle.

Bihenithyris deformata, new species
Bihenithyris species
Habrobrochus amygdaloideus, new species

S1468. Dhruma Formation (Zone not placed). Jebel Zahin, north side, 24°32′N, 46°00″E, Dhruma quadrangle.

Globirhynchia concinna, new species
G.? dubia, new species

S1469. Upper Dhruma Formation (Zone not placed). 1.2 km N 80°W of BG-9, Barra Graben, Wadi Atj quadrangle.

Arapsothyris magna, new species
Bihenithyris simulans, new species
Gyrosina? species
Xenorina ovata, new species

S1471. Upper Dhruma Formation (Zone not placed). 6 km S 42°W of Jebel Edh 'Dhu'anah, Dhruma quadrangle.

Apothyris aberrans, new species
Arapsothyris angustata, new species
Eurysites transversus, new species
Xenorina ovata, new species

S1476. Tuwaiq Mountain Formation. 24°59′54″N, 45°45′12″E, quandrangle not given.

Burmirhynchia decorticata, new species
Kutchithyris? species 1
Sphriganaria bicostata, new species
Xenorina ovata, new species

S1478. Upper Dhruma Formation (probably Atash member), no data.

Arabicella subpentagonalis, new species
Arapsothyris magna, new species
Sphriganaria angulocostata, new species
S. expansa, new species
Xenorina ovata, new species

S1482. Middle Dhruma Formation (36.4–41.4 m below *Micromphalites* Clay = *Thambites* Zone). 6.2 km N 86°W of Juraifa, 25°32′00″N, 45°11′54″E,

Shaqra quadrangle. (*Thambites* listed)

Conarosia concinna, new species
C. medialis, new species
C. ovata, new species
Deltarhynchia triangulata, new species

S1485. Lower Dhruma Formation (86–87 m below the *Micromphalites* Clay = *Ermoceras* Zone). On northeast corner of island in silt flat, 19.1 km S 27°15′E of Juraifa, 25°22′30″N, 45°20′48″E, Shaqra quadrangle.

Cymatorhynchia? singularis, new species
Echyrosia costata, new species
Globirhynchia? crassa, new species
Plectothyris? species
Sphenorhynchia varicostata, new species
Toxonelasma arabicum, new species

S1486. Middle Dhruma Formation (0–3 m below *Micromphalites* Clay = *Tulites* Zone). 14.9 km S 39°E of western gardens of Juraifa, 25°25′30″N, 45°21′18″E, Shaqra quadrangle.

Globirhynchia concinna, new species
Sphriganaria modesta, new species

S1488. Middle Dhruma Formation (3–11 m below the *Micromphalites* Clay = *Tulites* Zone). 14.9 km S 39°E of Juraifa, 25°25′30″N, 45°21′18″E, Shaqra quadrangle.

Burmirhynchia decorticata, new species
Conarosia angustata, new species
C. concinna, new species
Globirhynchia concinna, new species
Somalirhynchia somalica (Dacqué)
Sphenorhynchia varicostata, new species
Sphriganaria modesta, new species

S1496. Middle Dhruma Formation (3.7–20.6 m above base of *Micromphalites* fauna = *Micromphalites* Zone). Isolated hill 18 km N 60°W of Khashm Hisan, approximately 25°10′N, 45°42′30″E, Shaqra quandrangle.

Arapsothyris magna, new species
Burmirhynchia decorticata, new species
Daghanirhynchia angulocostata, new species
Gibbirhynchia sphaerica, new species
Globirhynchia subtriangulata, new species

S1498. Middle Dhruma Formation (13–16.3 m above base of *Micromphalites* Clay = *Micromphalites* Zone). 6 km N 58°W of Juraifa, 25°33′30″N, 45°12′36″E, Shaqra quadrangle. (*Micromphalites* listed)

Burmirhynchia decorticata, new species
Daghanirhynchia angulocostata, new species
Globirhynchia subtriangulata, new species

S1500. Middle Dhruma Formation (0–2 m above the base of the *Micromphalites* Clay = *Micromphalites* Zone). 5.9 km N 62°W of Juraifa, 25°33′18″N, 45°12′30″E, Shaqra quadrangle. (*Micromphalites* listed)

Daghanirhynchia angulocostata, new species
Globirhynchia concinna, new species
G.? dubia, new species

S1501. Middle Dhruma Formation (36.4–43.8 m below base of *Micromphalites* red shale = *Thambites* Zone). 7 km N 82°W of Juraifa, 25°32′18″N, 45°11′30″E, Shaqra quadrangle.

Burmirhynchia cuneata, new species
Conarosia angustata, new species
C. concinna, new species
C. medialis, new species
C. rotundata, new species
C. sphenoidea, new species
Deltarhynchia triangulata, new species
Eurysites rotundus, new species
Gibbirhynchia mundula, new species
Globirhynchia? dubia, new species
Sphriganaria magharensis (Farag), new combination
S. nasuta, new species

S1502. Middle Dhruma Formation (36.4–38.4 m below the *Micromphalites* Clay = *Thambites* Zone). 3.8 km N 89°W of Juraifa, 25°31′48″N, 45°13′18″E, Shaqra quadrangle.

Sphriganaria modesta, new species

S1503. Middle Dhruma Formation (39.4–40.4 m below the *Micromphalites* Clay = *Thambites* Zone). Locality same as S1502.

Baeorhynchia elegantula, new species
B. nucleata, new species
Colpotoria plicatilis, new species
Conarosia rotundata, new species
C. sphenoidea, new species
Deltarhynchia triangulata, new species
Eurysites rotundus, new species
Sphenorhynchia varicostata, new species
Sphriganaria magharensis (Farag), new combination
S. modesta, new species

S1505. Middle Dhruma Formation (39.4–40.4 m below *Micromphalites* Clay = *Thambites* Zone). 5.25 km N 85°W of Juraifa, 25°32′00″N, 45°12′30″E, Shaqra quadrangle.

Conarosia sphenoidea, new species
Sphriganaria modesta, new species

S1506. Lower Dhruma Formation (86–87 m below *Micromphalites* Clay = *Ermoceras* Zone). 19.1 km N 52.15°E of Juraifa, 25°22′30″N, 45°20′48″E, Shaqra quadrangle.

Cymatorhynchia? singularis, new species
Echyrosia costata, new species
Globirhynchia? crassa, new species
Sphenorhynchia varicostata, new species

S1508. Middle Dhruma Formation (80–85 m above the base of the *Micromphalites* fauna = top of *Dhrumaites* Zone). 5.6 km S 41°W of Khashm Hisan in promontory, 25°02′36″N, 45°50′00″E, Wadi Atj quadrangle.

Colpotoria plicatilis, new species

S1596. Middle Dhruma Formation (38 m above the Dhibi Member = *Thambites* Zone). Khashm Hartam, Hamr quadrangle.

Burmirhynchia decorticata, new species

S1612. Dhruma Formation (Zone not placed). On south slope of Jebel Bukarat, from the jebel to a point 1 km due south, 25°19′06″N, 45°45′54″E, Wadi Atj quadrangle.

Colpotoria plicatilis, new species

S1613. Upper Dhruma Formation (Zone not placed). Same locality as S1612.

Daghanirhynchia angulocostata, new species
D. sulcata, new species
D.? triangulata, new species

S1615. Upper Dhruma Formation (probably Hisyan Member). Same locality as S1612.

Ectyphoria inflata, new species
Striithyris striata, new species

S1617. Lower Dhruma Formation (*Ermoceras* Zone). Same locality as S1485.

Globirhynchia? crassa, new species
Sphenorhynchia varicostata, new species

S1618. Lower Dhruma Formation (88–90 m below *Micromphalites* Clay = *Ermoceras* Zone). 4.5 km S 50°(57½°) W of west end of gardens of Juraifa, 25°30′06″N, 45°13′36″E, Shaqra quadrangle. (*Ermoceras striga-tum* listed)

Burmirhynchia? bicostata, new species
Echyrosia costata, new species
Gibbirhynchia subcircularis, new species
Globirhynchia? dubia, new species
G. triangulata, new species
Sphaeroidothyris species 2
Sphriganaria bicostata, new species
Toxonelasma arabicum, new species

S1619. LowerDhruma Formation (86–88 m below *Micromphalites* Clay = *Ermoceras* Zone). Same locality as S1618.

Sphriganaria species 1

S1620. Middle Dhruma Formation (*Thambites* Zone). 25°32′18″N, 45°11′30″E, Shaqra quadrangle. (*Thambites planus* listed)

Conarosia sphenoidea, new species
Deltarhynchia compacta, new species
D. triangulata, new species
Sphriganaria nasuta, new species

S1621. Middle Dhruma Formation (20.7–21.7 m below *Micromphalites* Clay = *Tulites* Zone). 8.4 km N 68°W of Juraifa, 25°33′30″N, 45°10′54 E, Shaqra quadrangle.

Globirhynchia concinna, new species
Sphriganaria angustata, new species
S. bicostata, new species

S1628. Marrat Formation (*Nejdia* Zone). 23°56′36″N, 46°11′00″E, Birk quadrangle. (*Nejdia bramkampi* listed)

Liospiriferina obesa, new species

S1629. Middle Dhruma Formation (15.7–20.7 m below *Micromphalites* Clay = *Tulites* Zone). Same locality as S1621.

Globirhynchia subtriangulata, new species

S1644. Dhruma Formation (Zone not placed). In of a series of measured sections between 10.3 km S 85°W of Esh Shi 'ib (northwest corner) to 500 m southeast of Esh Shi 'ib, 22°01′36″N to 22°01′48″N, 45°51′36″E to 45°57′36″E, Hamr quadrangle.

Daghanirhynchia angulocostata, new species
Eurysites rotundus, new species
Kallirhynchia dispar, new species

S1652. Dhruma Formation (93–160 m below top of *Dhrumaites* Zone = Zone not placed). 23°26′18″N, 46°28′48″E, quadrangle not given.

Burmirhynchia decorticata, new species
Colpotoria magna, new species
Daghanirhynchia angulocostata, new species
Pycnoria magna, new species
Sphenorhynchia varicostata, new species

S1661. Lower Dhruma Formation (*Ermoceras* Zone). 24°04′06″N, 46°12′36″E, quadrangle not given.

Gibbirhynchia rotundata, new species
Schizoria elongata, new species
S. rotundata, new species

S1674. Tuwaiq Mountain Formation (72.7–88.5 m above base). 25°42′06″N, 45°13′06″E, Shaqra quadrangle.

Burmirhynchia rostrata, new species
Kallirhynchia arabica, new species

S1675. Tuwaiq Mountain Formation (146.7–158 m above base). Same locality as S1674.

Rhynchonellacean genus and species undetermined 1
Somalirhynchia prearabica, new species

S1676. Upper Dhruma Formation (28–30.5 m below top of Dhruma Formation = Hisyan Member). Aqaba Lidarub, 25°42′06″N, 45°13′06″E, Shaqra quadrangle.

Sphriganaria bramkampi, new species
Xenorina ovata, new species

S1677. Lower Dhruma Formation (*Ermoceras* Zone). 1.4 km S 8°W of S1485, 25°21′48″N, 45°20′42″E, Shaqra quadrangle.

Echyrosia circularis, new species
E. costata, new species
E. expansa, new species
Globirhynchia? crassa, new species
Lirellarina costellata, new species
Schizoria dividicostata, new species
S. intercalata, new species
S. intermedia, new species

S1679. Lower Dhruma Formation (*Ermoceras* Zone). 3.4 km S 50°E of S1485, from low rise above silt flat, 25°21′24″N, 45°22′18″E, Shaqra quadrangle. (*Ermoceras?* listed)

Globirhynchia? dubia, new species
Nastosia coangustata, new species

S1682. Hanifa Formation. Western conical Hanifa jebel on north side of Wadi Atj, 25°17′30″N, 45°46′00″E, Wadi Atj quadrangle.

Somalirhynchia arabica, new species

S1684. Middle Dhruma Formation (10.5 m below *Micromphalites* Clay = *Tulites* Zone). 10 km S 39°E from Juraifa, 25°27′36″N, 45°19′12″E, Shaqra quadrangle.

Daghanirhynchia angulocostata, new species

S1685. Middle Dhruma Formation (*Dhrumaites* Zone). About 2.3 km north of Zeb Hamudh, Dhruma quadrangle.

Sphriganaria bramkampi, new species

S1687. Dhruma Formation (Zone not placed). Dump of old well, 1 km west of conglomerate outcrop, on east edge of Negud Beladin, Dhruma quadrangle.

Sphaeroidothyris sphaeroidalis (Auct.)

S1688. Dhruma formation (Zone not placed). Just east of road, about 2.5 km northeast of conglomerate outcrop, 25°09′00″N, 45°40′30″E, Dhruma quadrangle.

Conarosia concinna, new species
C. medialis, new species
C. ovata, new species

S1695. Lower Dhruma Formation (*Ermoceras* Zone). 500 m southwest of S1504 [7 km S 78°W of Juraifa], 25°30′51″N, 45°11′12″E, Shaqra

quadrangle. (*Ermoceras* listed)

Globirhynchia triangulata, new species
Sphenorhynchia varicostata, new species
Stiphrothyris? species 2

S1702. Tuwaiq Mountain Formation. About 12 km due west of Khashm Hayal, on west side of Majma'a Graben, Shaqra quadrangle.

Dissoria costata, new species
D. obscura, new species
Glyphysaria? species
Pleuraloma labiatum, new species
P. multicostatum, new species
P. subaequicostatum, new species
P. triangulatum, new species
P. varicostatum, new species
Somalirhynchia somalica (Dacqué)

S1712. Tuwaiq Mountain Formation. Barra Graben, 2.15 km N 42.25°W of Jebel Adh Duwaina, 24°57′15″N, 45°47′18″E, Dhruma quadrangle.

Arabicella subpentagonalis, new species

S1715. Tuwaiq Mountain Formation. 11.6 km S 34½°E of Al Qarainan, 25°02′12″N, 45°41′00″E, Wadi Atj quadrangle.

Somalirhynchia deficiens, new species
Pleuraloma robustum, new species
Pleuraloma species

S1724. Upper Dhruma Formation (3.5 m below contact with Tuwaiq Mountain Formation = Hisyan Member). 25°56′54″N, 45°47′12″E, Wadi Atj quadrangle.

Daghanirhynchia angulocostata, new species
Somalirhynchia somalica (Dacqué)
Sphriganaria bramkampi, new species

S1730. Upper Dhruma Formation (possibly Atash Member). 0.7 km S 70.75°E of BG-9, 25°02′48″N, 45°40′36″E, Wadi Atj quadrangle.

Arabicella subplana, new species
Arapsothyris magna, new species
Somalirhynchia deficiens, new species
Xenorina ovata, new species

S1738. Middle Dhruma Formation (Just below *Micromphalites* Clay = *Tulites* Zone). 127½°(magnetic azimuth) to Jebel Farida and 149°to Jebel Fahdah, Shaqra quadrangle.

Globirhynchia concinna, new species
G. subtriangulata, new species
Kallirhynchia dispar, new species

S1742. Upper Dhruma Formation (Zone not placed). 25°23′15″N, 45°37′30″E, Wadi Atj quadrangle.

Eurysites transversus, new species
Sphriganaria expansa, new species
Xenorina ovata, new species

S1743. Dhruma Formation (Zone not placed). About 5.5 km north-northwest of S1485, Shaqra quadrangle.

Conarosia concinna, new species
C. medialis, new species
C. rotundata, new species
Sphriganaria angulocostata, new species

S1747. Middle Dhruma Formation (*Tulites* Zone). 13.75 km S 84½°W of Khashm Hisan, 25°04′04″N, 45°43′58″E, Shaqra quadrangle.

Eurysites rotundus, new species
Sphriganaria costata, new species
S. magharensis (Farag), new combination
S. magnicostata, new species

S1755. Dhruma Formation (Zone not placed). 5.62 m S 89½°W of Khashm Hisan, lower part of section, 25°04′48″N, 45°48′47″E, Wadi Atj quadrangle.

Pycnoria magna, new species

S1765. Middle Dhruma Formation (*Dhrumaites* Zone). 10.3 km S 85°W of Esh Shi'b (NW corner) to 500 m SE of Esh Shi'b 22°01′36″N, to 22°01′48″N, 45°51′36″E to 45°57′36″E, Hanir quadrangle.

Daghanirhynchia angulocostata, new species

S1784. Tuwaiq Mountain Formation. 0.68 m S 55°E of Jebel southeast of Haddar, 21°58′N, 45°58′E, Maqran quadrangle.

Daghanirhynchia angulocostata, new species

S1786. Dhruma Formation (Zone not placed). Section at Khashm Mishla, Mishla quadrangle.

Daghanirhynchia angulocostata, new species

S1787. Lower Dhruma Formation (*Dorsetensis* Zone). 3.5 km east of Jebel Abuer Rakhaim. 15.6 km N 11°W of Ain Bukhara. 24°18′22″N, 46°09′24″E, Dhruma quadrangle.

Baeorhynchia transversa, new species

S1788. Dhruma Formation (Zone not placed). 24°18′57″N, 46°13′00″E, Dhruma quadrangle.

Conarosia ovata, new species

S1789. Dhruma Formation (Zone not placed). 24°18′57″N, 46°13′00″E, Dhruma quadrangle.

Conarosia ovata, new species

S1790. Dhruma Formation (Zone not placed). Section west of Ghat-Ghat, Dhruma quadrangle.

Bihenithyris triangulata, new species
Conarosia medialis, new species

Astro 61. Location not given.

Pycnoria compacta, new species

Joint Collections of Aramco and Smithsonian Institution, 1962

KK numbers represent collections made by E.G. Kaufman, and P.M. Kier of the Smithsonian Institution and R.W. Powers, H.A. Maclure, and C.D. Redmond of the Arabian-American Oil Company in 1962. KK with an initial number indicates the location of the measured section. The following number is the distance in meters above the base of the section. The ammonite zones were determined by R.W. Imlay (1970) on the basis of the collections made by the party of 1962.

KK6. 24°13′16″N to 24°13′20″N, 46°06′18″E to 46°06′41″E southwest of Riyadh.

KK6. Lower Dhruma Formation (upper ⅓ of yellow marl in lower Dhruma below Dhibi member = *Dorsetensis* Zone)

Baeorhynchia cuneata, new species
B. nitida, new species

Gibbirhynchia costata, new species
G. magna, new species
G. parva, new species

KK6–14. Marrat Formation (*Bouleiceras* Zone)

Calyptoria carinata, new species
Conarosia matutina, new species

KK7. 24°11′17″N to 24°11′54″N, 46°11′10″E to 46°11′28″E, southwest of Riyadh.

KK7-3+1. Lower Dhruma Formation (*Ermoceras* Zone). Specimen probably from float.

Strongyloria circularis, new species

KK7–KK7–96. Lower Dhruma Formation (*Dorsetensia* Zone)

Baeorhynchia cuneata, new species
B. nitida, new species
Gibbirhynchia pulcher, new species
G. rotundata, new species
Orthotoma? species
Sphriganaria bicostata, new species
S. concentrica, new species
S. rara, new species
S. subcircularis, new species

KK7–130.5–KK7-133. Lower Dhruma Formation (*Ermoceras* Zone)

Conarosia medialis, new species
Sphriganaria distans, new species
S. distincta, new species

KK7-134–KK7-138. Middle Dhruma Formation (*Thambites* Zone)

Conarosia sphenoidea, new species
Sphriganaria bicostata, new species

KK8, KK8A, KK8B. 24°11′04″N to 24°11′13″N, 46°17′15″E to 46°17′16″E, southwest of Riyadh (KK8A and KK8B are same locality as KK8).

KK8–KK8-5.5 Lower Dhruma Formation (*Ermoceras* Zone)

Conarosia rotundata, new species
Sphaeroidothyris sphaeroidalis (Auct.)
Sphriganaria costellata, new species

KK8-6–KK8-38. Middle Dhruma Formation (*Thambites* Zone)

Burmirhynchia decorticata, new species
Conarosia angustata, new species
C. concinna, new species
C. medialis, new species
C. ovata, new species
C. rotundata, new species
C. sphenoidea, new species
Daghanirhynchia angulocostata, new species
Eurysites rotundus, new species
E. transversus, new species
Sphriganaria angustata, new species
S. bicostata, new species
S. costata, new species
S. costellata, new species
S. distincta, new species
S. irregularis, new species
S. magharensis (Farag), new combination
S. modesta, new species
S. perovalis, new species
S. subcircularis, new species
Strongyloria subelliptica, new species

KK8-39–KK8A-58. Middle Dhruma Formation (*Tulites* Zone)

Conarosia concinna, new species
C. medialis, new species
C. ovata, new species
Eurysites rotundus, new species
Kallirhynchia obesa, new species
Sphriganaria costata, new species
S. costellata, new species
S. distincta, new species
S. magharensis (Farag), new combination

KK9. 24°11′19″N to 24°12′35″N, 46°18′51″E to 46°19′06″E, southwest of Riyadh.

KK9-9–KK9-72. Middle Dhruma Formation (*Micromphalites* Zone)

Arabicella subplana, new species
Burmirhynchia angustata, new species
B. decorticata, new species
Conarosia angustata, new species
C. medialis, new species
C. ovata, new species
C. rotundata, new species
Daghanirhynchia angulocostata, new species
Eurysites transversus, new species
Gibbirhynchia sphaerica, new species
Globirhynchia subtriangulata, new species
Kutchithyris? species 1
Pycnoria magna, new species
Sphriganaria costellata, new species
S. magharensis (Farag), new combination
S. obesa, new species
S. perovalis, new species

KK9-73–KK9-111. Middle Dhruma Formation (*Dhrumaites* Zone)

Arabicella ovalis, new species
A. subpentagonalis, new species
A. subplana, new species
Ectyphoria inflata, new species
Heteromychus magnificus, new species
Heteromychus species
Pseudowattonithyris? species
Pycnoria magna, new species
Sphriganaria angulocostata, new species
S. bramkampi, new species
S. capax, new species
S. concentrica, new species
S. magharensis (Farag), new combination
S. modesta, new species

KK9-112–KK9-123. Dhruma Formation (Atash Member) [Imlay (1970:D10) reports the ammonites *Pachyceras*, *Grossouvria*, and *Erymnoceras philbyi* = *Pachyerymnoceras*.]

Apothyris aberrans, new species
Arabicella ovalis, new species
A. subplana, new species
Bihenithyris quadrilobata, new species
Daghanirhynchia angulocostata, new species
D.? triangulata, new species
Ectyphoria inflata, new species
Heteromychus magnificus, new species
Pycnoria magna, new species
Sphriganaria bramkampi, new species
S. magharensis (Farag), new combination
Stenorina parallela, new species
Xenorina ovata, new species

KK10. 24°16′49″N to 24°16′53″N, 46°33′05″E to 46°33′15″E, southwest of Riyadh.

KK10–KK10-38. Hanifa Formation (lower 43 m).

Glyphisaria? divergens, new species
Habrobrochus amygdaloideus, new species
Mycerosia amygdaliformis, new species
Somalirhynchia africana Weir
S. arabica, new species
S. somalica (Dacqué)
Somalithyris elliptica, new species
S. ovata, new species
S. parva, new species
S. subcircularis, new species
S. triangulata, new species
Terebratulacean genus and species undetemined 1
Torquirhynchia parva, new species

Appendix III

Faunal Lists by Formation

MARRAT FORMATION

Bouleiceras Zone

RHYNCHONELLACEA

Conarosia matutina, new species

SPIRIFERINACEA

Calyptoria carinata, new species
C. extensa, new species
Liospiriferina obesa, new species
L. vulgata, new species
Spririferina species 1, 2, 3

ZEILLERIACEA

Apothyris species
Rugitela primaria, new species
Zeilleria? species 2

Nejdia Zone

SPIRIFERINACEA

Liospiriferina obesa, new species

LOWER DHRUMA FORMATION

Dorsetensia Zone

RHYNCHONELLACEA

Baeorhynchia cuneata, new species
B. nitida, new species
B. transversa, new species
Gibbirhynchia costata, new species
G. magna, new species
G. parva, new species
G. pulcher, new species
G. rotundata, new species
Schizoria elongata, new species

TEREBRATULACEA

Orthotoma? species

ZEILLERIACEA

Sphriganaria bicostata, new species
S. concentrica, new species
S. rara, new species
S. subcircularis, new species

RHYNCHONELLACEA

Baeorhynchia carinata, new species
B. nitida, new species
Schizoria costellata, new species
S. elongata, new species
S. secta, new species

Ermoceras Zone

RHYNCHONELLACEA

Amydroptychus formosus, new species
Burmirhynchia? bicostata, new species
Conarosia medialis, new species
C. ovata, new species
C. rotundata, new species
Cymatorhynchia? singularis, new species
Echyrosia circularis, new species
E. costata, new species
E. expansa, new species
Gibbirhynchia rotundata, new species
G. subcircularis, new species
Globirhynchia? crassa, new species
G.? dubia, new species
G. triangulata, new species
Lirellarina costellata, new species
Nastosia coangustata, new species
N.? convexa, new species
Schizoria costellata, new species
S. dividicostata, new species
S. elongata, new species
S. intercalata, new species
S. intermedia, new species
S. rotundata, new species
Schizoria species 1, 2
Sphenorhychia varicostata, new species
Strongyloria circularis, new species

TEREBRATULACEA

Loboidothyris? species
Plectothyris? species
Sphaeroidothyris arabica, new species
S. sphaeroidalis (Auct.)
Sphaeroidothyris species 1, 2
Stiphrothyris? species 1, 2
Terebratulacean genus and species undetermined 2, 3
Toxonelasma arabicum, new species

ZEILLERIACEA

Sphriganaria angustata, new species
S. bicostata, new species
S. costellata, new species
S. distans, new species
S. distincta, new species
S. eximia, new species
S. irregularis, new species
S. magharensis (Farag), new combination

S. varicostata, new species
Sphriganaria species 1

MIDDLE DHRUMA FORMATION

Thambites Zone

RHYNCHONELLACEA

Baeorhynchia elegantula, new species
B. nucleata, new species
Burmirhynchia cuneata, new species
B. decorticata, new species
Colpotoria plicatilis, new species
Conarosia angustata, new species
C. concinna, new species
C. medialis, new species
C. ovata, new species
C. rotundata, new species
C. sphenoidea, new species
Conarosia species 1
Daghanirhynchia angulocostata, new species
Deltarhynchia compacta, new species
D. triangulata, new species
Eurysites rotundus, new species
E. transversus, new species
Gibbirhynchia mundula, new species
Globirhynchia? dubia, new species
G. subtriangulata, new species
Sphenorhynchia varicostata, new species
Strongyloria subelliptica, new species

TEREBRATULACEA

Sphaeroidothyris arabica, new species

ZEILLERIACEA

Flabellothyris flabella (Defrance)
Sphriganaria angustata, new species
S. bicostata, new species
S. costata, new species
S. costellata, new species
S. distincta, new species
S. elliptica, new species
S. irregularis, new species
S. lirata, new species
S. magharensis (Farag), new combination
S. modesta, new species
S. nasuta, new species
S. perovalis, new species
S. subcircularis, new species

Tulites Zone

RHYNCHONELLACEA

Burmirhynchia decorticata, new species
Conarosia angustata, new species
C. concinna, new species
C. medialis, new species
C. ovata, new species
Daghanirhynchia angulocostata, new species
Eurysites rotundus, new species
Globirhynchia concinna, new species
G. subtriangulata, new species
Kallirhynchia arabica, new species
K. dispar, new species
K. obesa, new species
K. orbicularis, new species
Kutchirhynchia arabica, new species
Somalirhynchia somalica (Dacqué)
Sphenorhynchia? angulata, new species
S. varicostata, new species

ZEILLERIACEA

Apothyris aberrans, new species
Sphriganaria angustata, new species
S. bicostata, new species
S. costata, new species
S. costellata, new species
S. distincta, new species
S. magharensis (Farag), new combination
S. magnicostata, new species
S. modesta, new species
S. parva, new species

Micromphalites Zone

RHYNCHONELLACEA

Burmirhynchia angustata, new species
B. decorticata, new species
Colpotoria plicatillis, new species
Conarosia angustata, new species
C. medialis, new species
C. ovata, new species
C. rotundata, new species
Daghanirhynchia angulocostata, new species
D.? triangulata, new species
Eurysites transversus, new species
Gibbirhynchia sphaerica, new species
Globirhynchia concinna, new species
G.? dubia, new species
G. subtriangulata, new species
Pycnoria magna, new species

TEREBRATULACEA

Arabicella subpentagonalis, new species
A. subplana, new species
Arapsothyris magna, new species
Kutchithyris? species 1

ZEILLERIACEA

Sphriganaria costellata, new species
S. curtirostra, new species
S. magharensis (Farag), new combination
S. obesa, new species
S. perovalis, new species
Xenorina ovata, new species

Dhrumaites Zone

RHYNCHONELLACEA

Burmirhynchia decorticata, new species
Colpotoria plicatilis, new species
Conarosia medialis, new species
Daghanirhynchia angulocostata, new species
Globirhynchia subtriangulata, new species
Heteromychus magnificus, new species
Heteromychus species
Pycnoria magna, new species

TEREBRATULACEA

Arabicella ovalis, new species
A. subpentagonalis, new species

A. subplana, new species
Arapsothyris magna, new species
Ectyphoria inflata, new species
Kutchithyris? species 1
Pseudowattonithyris? species

ZEILLERIACEA

Sphriganaria angulocostata, new species
S. bramkampi, new species
S. canax, new species
S. concentrica, new species
S. magharensis (Farag), new combination
S. modesta, new species
Xenorina ovata, new species

Atash Member

RHYNCHONELLACEA

Daghanirhynchia angulocostata, new species
D.? triangulata, new species
Heteromychus magnificus, new species
Fycnoria magna, new species
Somalirhynchia deficiens, new species

TEREBRATULACEA

Arabicella ovalis, new species
A. subpentagonalis, new species
A. subplana, new species
Arapsothyris magna, new species
Bihenithyris quadrilobata, new species
Ectyphoria inflata, new species
Stenorina parallela, new species

ZEILLERIACEA

Apothyris aberrans, new species
Sphriganaria angulocostata, new species
S. bramkampi, new species
S. expansa, new species
S. magharensis (Farag), new combination
Xenorina ovata, new species

Upper Atash–Lower Hysian Members

ZEILLERIACEA

Apothyris aberrans, new species
Sphriganaria magharensis (Farag), new combination

Hisyan Member

RHYNCHONELLACEA

Daghanirhynchia angulocostata, new species
D.? triangulata, new species
Pycnoria magna, new species
Somalirhynchia arabica, new species
S. somalica (Dacqué)

TEREBRATULACEA

Ectyphoria inflata, new species
Striithyris striata, new species

ZEILLERIACEA

Sphriganaria bramkampi, new species
S. capax, new species
S. expansa, new species
S. intercalata, new species
Xenorina ovata, new species

Zone Not Placed

RHYNCHONELLACEA

Burmirhychi.? cuneata, new species
B. decorticata, new species
B. rostrata, new species
B. subnasuta, new species
Colpotoria magna, new species
C. plicatilis , new species
Conarosia angustata, new species
C. concinna, new species
C. medialis, new species
C. ovata, new species
C. rotundata, new species
Daghanirhynchia angulocostata, new species
D. sulcata, new species
Echyrosia costata, new species
Eurysites rotundus, new species
E. transversus, new species
Globirhynchia concinna, new species
G.? dubia, new species
G. subtriangulata, new species
Kallirhynchia dispar, new species
Pycnoria compacta, new species
P. magna, new species
Sphenorhynchia varicostata, new species

TEREBRATULACEA

Arabicella subpentagonalis, new species
Avonothyris? species
Bihenithyris triangulata, new species
Pionopleurum compactum, new species
P. obesum, new species
Sphaeroidothyris sphaeroidalis (Auct.)

ZEILLERIACEA

Sphriganaria angulocostata, new species
S. angustata, new species
S. argula, new species
S. bicostata, new species
S. capax, new species
S. costata, new species
S. costellata, new species
S. distincta, new species
S. magharensis (Farag), new combination
S. nasuta, new species

UPPER DHRUMA FORMATION

Zone Not Placed

RHYNCHONELLACEA

Daghanirhynchia angulocostata, new species
D. sulcata, new species
Eurysites rotundus, new species
E. transversus, new species

TEREBRATULACEA

Arabicella subpentagonalis, new species
A. subplana, new species
Arapsothyris angustata, new species
A. magna, new species

Bihenithyris simulans, new species
Gyrosina? species

ZEILLERIACEA

Apothyris aberrans, new species
Sphriganaria angulocostata, new species
S. bramkampi, new species
S. capax, new species
S. expansa, new species
S. modesta, new species
Xenorina ovata, new species

TUWAIQ MOUNTAIN FORMATION

RHYNCHONELLACEA

Burmirhynchia decorticata, new species
B. rostrata, new species
Daghanirhynchia angulocostata, new species
D. sulcata, new species
Eurysites rotundus, new species
E. transversus, new species
Kallirhynchia arabica, new species
Somalirhynchia arabica, new species
S. deficiens, new species
S. prearabica, new species
S. somalica (Dacqué)
Rhynchonellacean genus and species undetermined
Torquirhynchia? convexa, new species

TEREBRATULACEA

Apatecosia inornata, new species
A. varians, new species
Arabatia concava, new species
Arabicella? costata, new species
A. subpentagonalis, new species
Arapsopleurum arabicum, new species
A. dubium, new species
A. rotundum, new species
Arapsothyris angustata, new species
A. magna, new species
Bihenithyris? abnormis, new species
B. deformata, new species
B. mediocostata, new species
B. simulans, new species
B. species
Dissoria costata, new species
D. obscura, new species
D. tribulis, new species
Dolichobrochus? ovatus, new species
Glyphisaria? divergens, new species
Glyphisaria? species
Gyrosina ovata, new species
Habrobrochus amygdaloideus, new species
Kutchithyris? species 1, 2
Pionopleurum obesum, new species
Pleuraloma abruptum, new species
P. anomalum, new species
P.? circulare, new species
P. convexum, new species
P. labiatum, new species
P. multicostatum, new species
P. robustum, new species
P. subaequicostatum, new species
P. triangulatum, new species
P. varicostatum, new species
Pleuraloma species
Striithyris costata, new species
S. saudiarabica, new species
S. striata, new species
Tanyothyris angustata, new species
T. symmetrica, new species

ZEILLERIACEA

Apothyris aberrans, new species
Mycerosia amygdaliformis, new species
Sphriganaria bicostata, new species
S. bramkampi, new species
Xenorina ovata, new species
Zeilleria? species 1

HANIFA FORMATION

RHYNCHONELLACEA

Somalirhynchia africana Weir
S. arabica, new species
S. somalica (Dacqué)
Torquirhynchia? parva, new species

TEREBRATULACEA

Dorsoplicathyris? species
Glyphisaria? divergens, new species
Habrobrochus amygdaloideus, new species
Kutchithyris? species 1
Somalithyris elliptica, new species
S. ovata, new species
S. parva, new species
S. rotundata, new species
S. subcircularis, new species
S. triangulata, new species
Terebratulacean genus and species undetermined 1

ZEILLERIACEA

Mycerosia amygdaliformis, new species
Sphriganaria species 2

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Plates

PLATE 1

FIGURES 1–15.—*Amydroptychus formosus*, new species: 1–5, anterior, posterior, side, ventral, and dorsal views, ×1, paratype, USNM 380223a. 6–10, anterior, posterior, side, ventral, and dorsal views, ×1, holotype, USNM 380223c. 11–15, anterior, dorsal, posterior, ventral, and side views, ×1, young paratype, USNM 380223b. Locality S1409.

FIGURES 16–21.—*Baeorhynchia carinata*, new species, holotype, USNM 380268: 16, dorsal view, ×1; 17–21, posterior, anterior, side, ventral, and dorsal views, ×2. Locality S99o.

FIGURES 22–27.—*Baeorhynchia cuneata*, new species, holotype, USNM 380263a: 22, dorsal view, ×1, 23–27, posterior, side anterior, ventral, and dorsal views, ×2. Locality KK7-45.

FIGURES 28–33.—*Baeorhynchia elegantula*, new species, holotype, USNM 380499: 28, dorsal view, ×1; 29–33, anterior, posterior, side, ventral, and dorsal views, ×2. Locality S1503.

FIGURES 34–51.—*Baeorhynchia nitida*, new species: 34, dorsal view, ×1, paratype, USNM 380518a; 35–39, posterior, side, anterior, dorsal, and ventral views, ×2, of the same paratype; 40, dorsal view, ×1, of the holotype, USNM 380267a; 41–45, posterior, anterior, side, ventral, and dorsal views, ×2, holotype. 46, dorsal view, ×1, paratype, USNM 380267d; 47–51, ventral, posterior, side, anterior, and dorsal views, ×2, of the same paratype, USNM 380267d. Locality KK7-35.

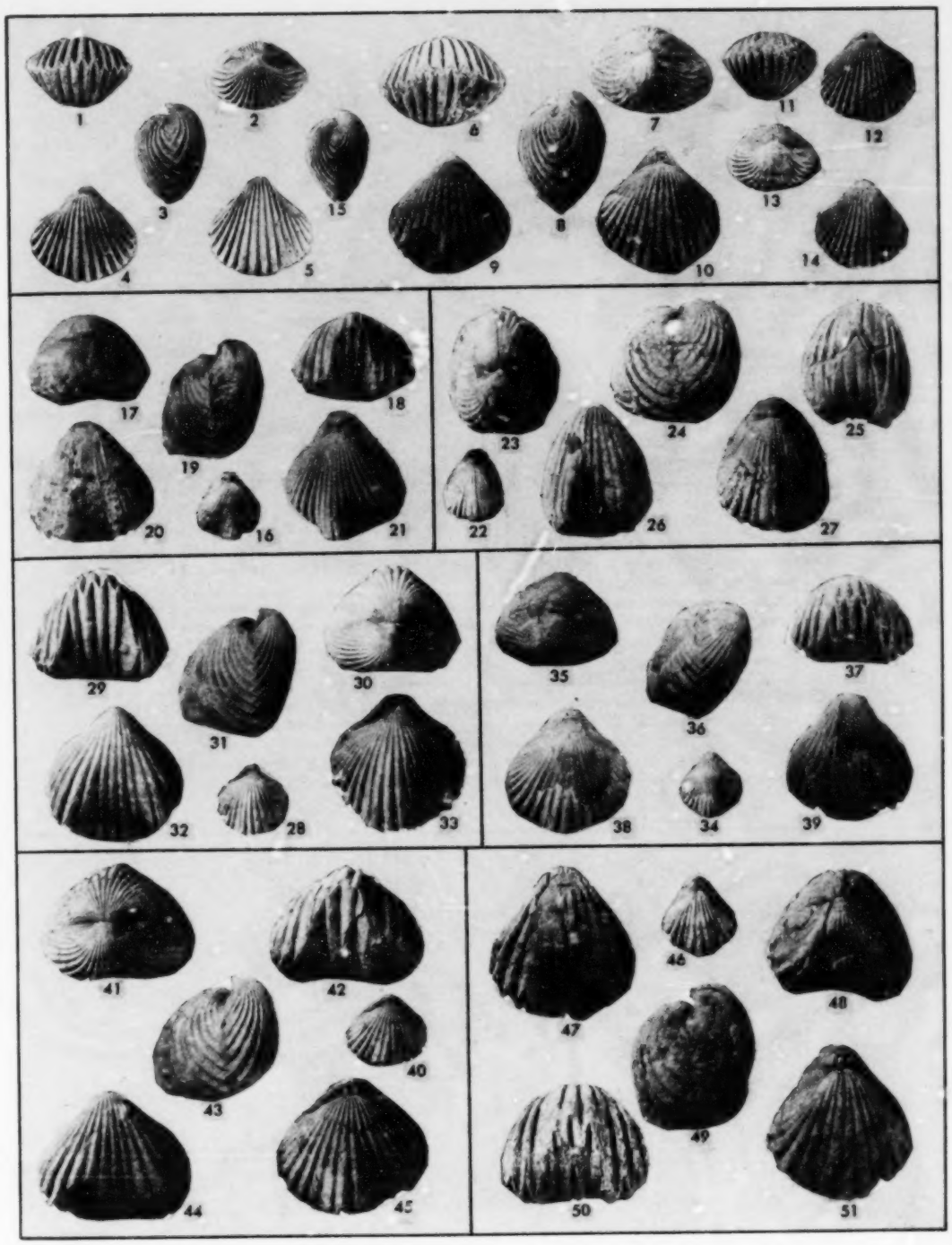
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PLATE 2

FIGURES 1–6.—*Baeorhynchia transversa*, new species, holotype, USNM 380258: 1, dorsal view, ×1; 2–6, posterior, anterior, side, dorsal, and ventral views, ×2. Locality S1787.

FIGURES 7–12.—*Baeorhynchia nucleata*, new species, holotype, USNM 380264a: 7, dorsal view, ×1; 8–12, anterior, posterior, ventral, side, and dorsal views, ×2. Locality S1503.

FIGURES 13–20.—*Burmirhynchia rostrata*, new species, holotype, USNM 380212a: 13–17, posterior, ventral, dorsal, anterior, and side views, ×1; 18–20, dorsal, anterior, and side views, ×2. Locality S1674.

FIGURES 21–25.—*Burmirhynchia subnasuta*, new species, holotype, USNM 380225: posterior, anterior, side, ventral, and dorsal views, ×1. Locality S1414.

FIGURES 26–35.—*Burmirhynchia decorticata*, new species: 26–30, posterior, side, dorsal, ventral, and anterior views, ×1, paratype, USNM 380257a; 31–35, ventral, side, anterior, posterior, and dorsal views, ×1, of the holotype, USNM 380383a. Localities: 26–30, S1498; 31–35, KK9-21.

FIGURES 36–40.—*Burmirhynchia cuneata*, new species, holotype, USNM 380227: anterior, posterior, side, dorsal, and ventral views, ×1. Locality S1448.

FIGURES 41–49.—*Burmirhynchia angustata*, new species: 41–45, dorsal, anterior, side, ventral, and posterior views, ×1, holotype, USNM 380224a; 46–48, side, dorsal, and anterior views, ×2, of the holotype; 49, cross-section at plane of articulation, ×2, paratype, USNM 380637. Locality KK9-22.5.

FIGURES 50–57.—*Burmirhynchia? bicostata*, new species, holotype, USNM 380226: 50–54, side, posterior, ventral, anterior, and dorsal views, ×1; 55–57, side, dorsal, and anterior views, ×2. Locality S1618.

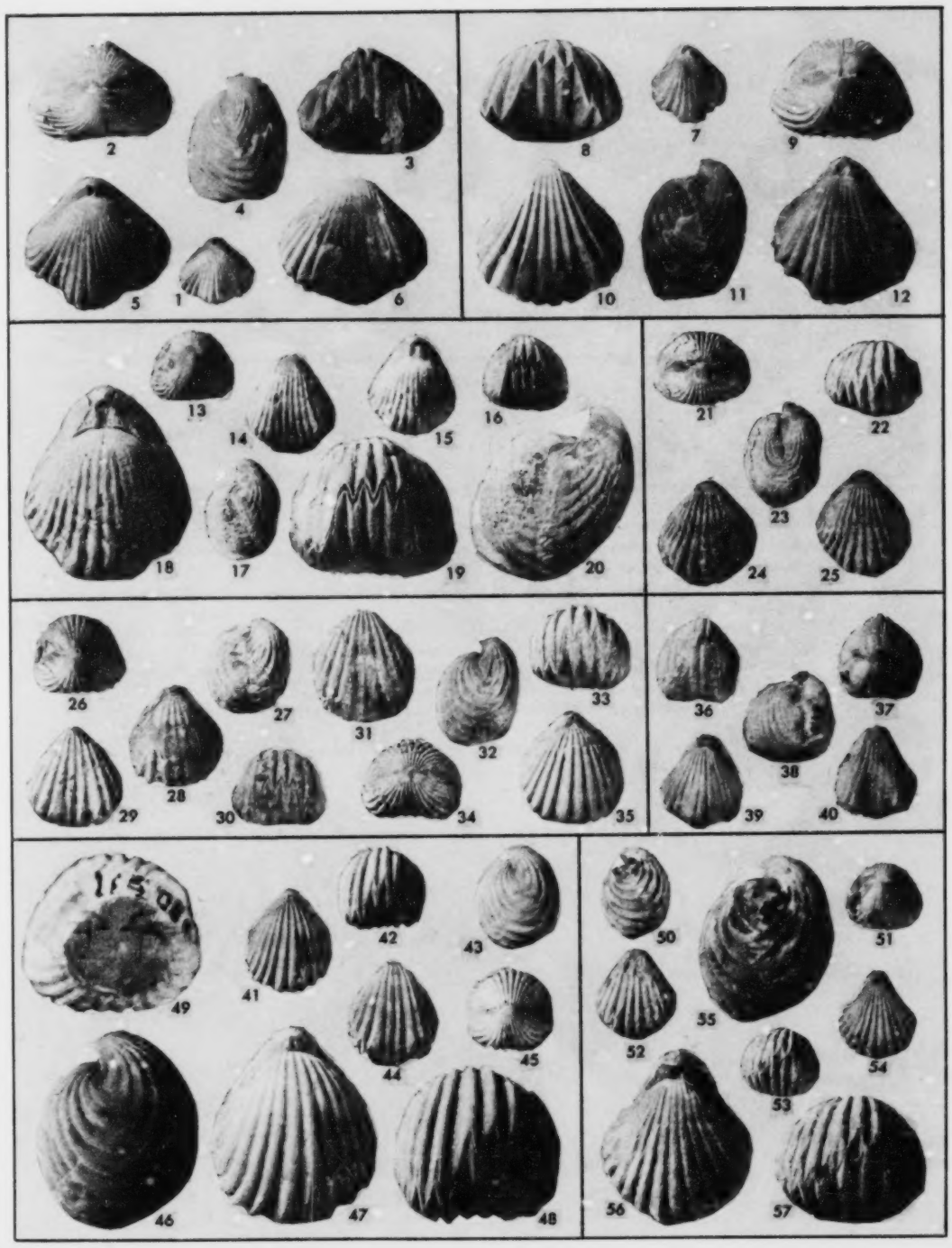
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PLATE 3

FIGURES 1–16.—*Conarosia concinna*, new species: 1–5, anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380213; 6–10, ventral, posterior, dorsal, side, and anterior views, ×1, of a paratype, USNM 380460; 11–15, dorsal, side, posterior, ventral, and anterior views, ×1, paratype, USNM 380461; 16, cross-section at the plane of articulation, ×2, of a paratype, USNM 380294 (see figure 9, above). Localities: 1–5, KK8-39.5; 6–10, S1422; 11–15, S1046; 16, S1160.

FIGURES 17–21.—*Conarosia matutina*, new species, holotype, USNM 380276: dorsal, posterior, ventral, anterior, and side views, ×1. Locality KK6-14.

FIGURES 22–26.—*Conarosia angustata*, new species, holotype, USNM 380649: posterior, ventral, side, anterior, and dorsal views, ×1. Locality S1418.

FIGURES 27–42.—*Colpotoria plicatilis*, new species: 27–31, ventral, dorsal, side, anterior, and posterior views, ×1, holotype, USNM 380208a. 32, dorsal view of the beak of the holotype, ×2; 33–35, anterior, side, and dorsal views, ×1, of a paratype showing strong anterior plication, USNM 380208c; 36–40, posterior, dorsal, ventral, side, and anterior views, ×1, of a young paratype, USNM 380208e; 41, cross-section at plane of articulation, ×2, paratype, USNM 380208f; 42, anterior view, ×1, young paratype, USNM 380208d. Locality S1151.

FIGURES 43–47.—*Colpotoria magna*, new species: ventral, posterior, side, anterior, and dorsal views, ×1, holotype, USNM 380452. Locality S1652.

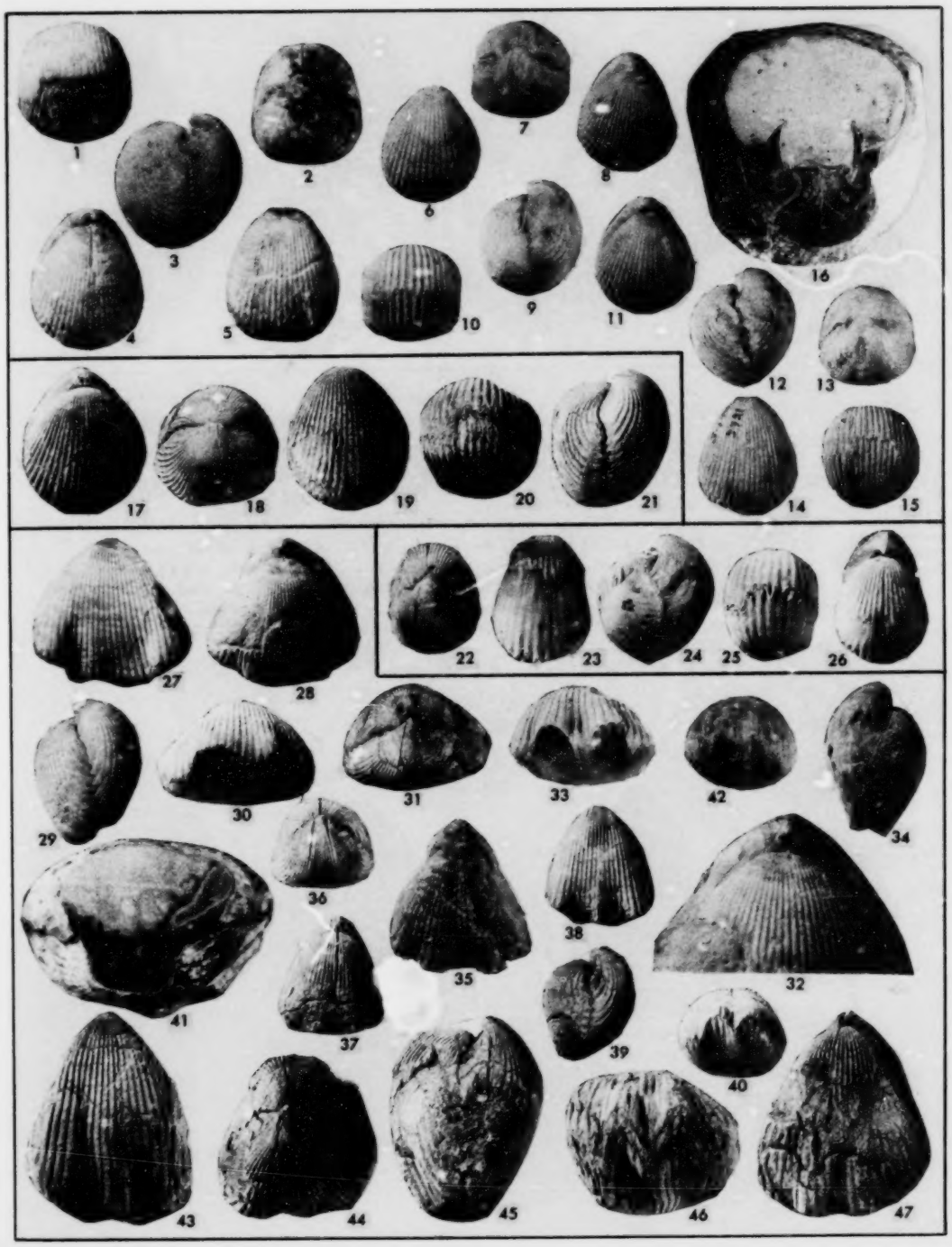
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PLATE 4

FIGURES 1–4.—*Conarosia* species: posterior, dorsal, side, and ventral views, ×1, of an imperfect, finely costate specimen, USNM 380382. Locality S1001.

FIGURES 5–9.—*Cymatorhynchia? singularis*, new species: posterior, anterior, side, ventral, and dorsal views, ×1, holotype, USNM 380517a. Locality S1485.

FIGURES 10–31.—*Conarosia rotundata*, new species: 10–14, ventral, dorsal, side, anterior, and posterior views, ×1, of a young paratype, USNM 380379; 15–19, ventral, anterior, dorsal, posterior, and side views, ×1, paratype, USNM 380360a; 20–24, side, dorsal, anterior, posterior,, and ventral views, ×1, of a larger paratype, USNM 380360b; 25–29, ventral, anterior, posterior, side, and dorsal views, ×1, of a large adult, holotype, USNM 380287a; 30, dorsal view, ×2, of the beak of the holotype showing dental and deltidial plates; 31, cross-section at the plane of articulation, ×2, paratype, USNM 380287c. Localities: 10–24, S1501; 25–31, S1503.

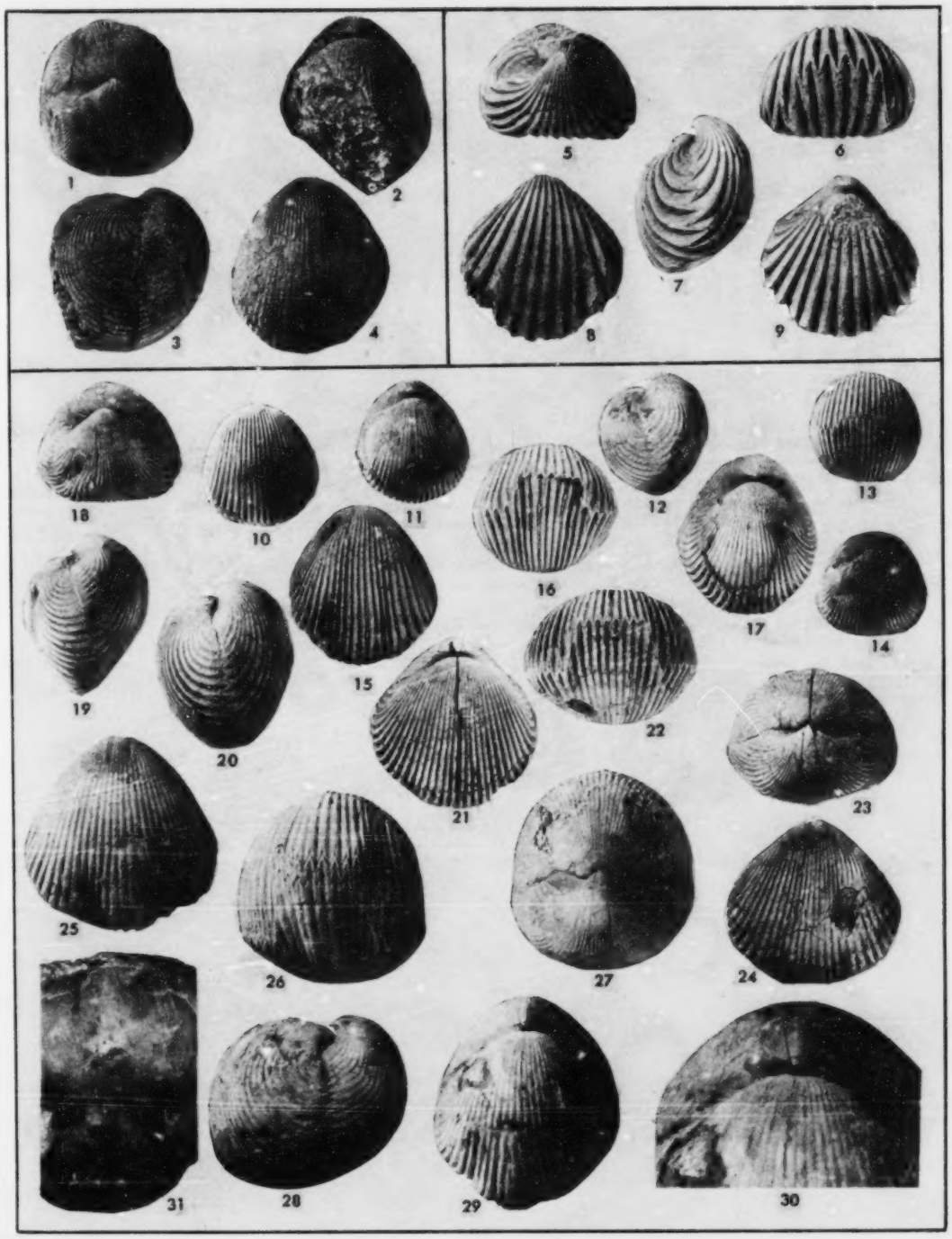
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PLATE 5

FIGURES 1–25.—*Conarosia sphenoidea*, new species: 1–5, ventral, anterior, side, dorsal, and posterior views, ×1, of a large paratype, USNM 380451; 6–10, anterior, posterior, side, dorsal, and ventral views, ×1, of a young paratype, USNM 380374a; 11–15, anterior, side, ventral, dorsal, and posterior views, ×1, of a small adult paratype, USNM 380210; 16–20, dorsal, anterior, side, ventral, and posterior views, ×1, holotype, USNM 380219b; 21–25, posterior, side, anterior, ventral, and dorsal views, ×1, of a large paratype, USNM 380219a (figure 25 slightly reduced). Locality S1503.

FIGURES 26–28.—*Heteromychus magnificus*, new species: 26, 27, side and posterior views, ×1, of an imperfect paratype, USNM 380288a; 28, cross-section at the plane of articulation, approximately ×2, paratype, USNM 380288d. Locality KK9-112.

FIGURES 29–38.—*Daghanirhynchia sulcata*, new species: 29–33, anterior, ventral, dorsal, side,, and posterior views, ×1, of a paratype, USNM 380274a; 34–38, posterior, dorsal, side, anterior, and ventral views, ×1, paratype, USNM 380274b. Locality S800.

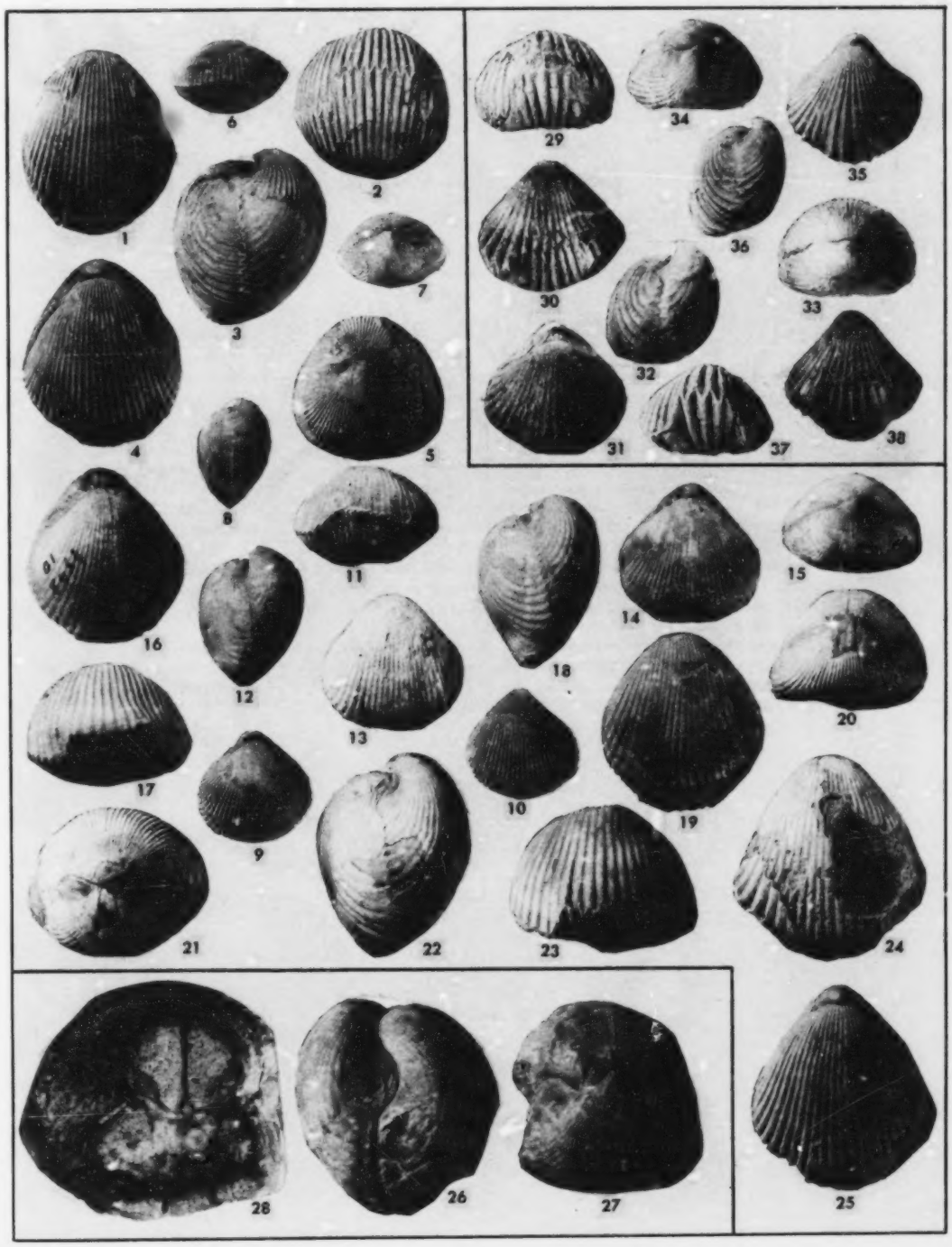
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PLATE 6

FIGURES 1–19.—*Daghanirhynchia angulocostata*, new species: 1–5, posterior, side, dorsal, ventral, and anterior views, ×1, of a paratype, USNM 380498a; 6–8, dorsal, side,, and anterior views, ×1, of an old paratype, USNM 380615; 9–13, anterior, posterior, ventral, dorsal, and side views, ×1, of a paratype, USNM 380520; 14–18, anterior, dorsal, side, ventral, and anterior views, ×1, paratype, USNM 380566; 19, beak, ×2, of the paratype, USNM 380566, showing anteriorly thickened, rimmed deltidial plates. Localities: 1–8, S1257; 9–13, S1118; 14–19, KK9-22.5.

FIGURES 20–29.—*Conarosia medialis*, new species: 20–24, anterior, ventral, dorsal, side, and posterior views, ×1, holotype, USNM 380278a (figure 24 shows closely spaced, subparallel dental plates); 25–29, ventral, side, posterior, anterior, and dorsal views, ×1, of the paratype, USNM 380214. Localities: 20–24, S1482; 25–29, S1447.

FIGURES 30–44.—*Conarosia ovata*, new species: 30–34, ventral, side, posterior, dorsal, and anterior views, ×1, paratype, USNM 380361; 35–39, posterior, ventral, anterior, dorsal, and side views, ×1, of a paratype, USNM 380280; 40–44, dorsa!, anterior, side, posterior, and ventral views, ×1, holotype, USNM 380459. Localities: 30–34, S1688; 35–39, KK8-37.5; 40–44, S1119.

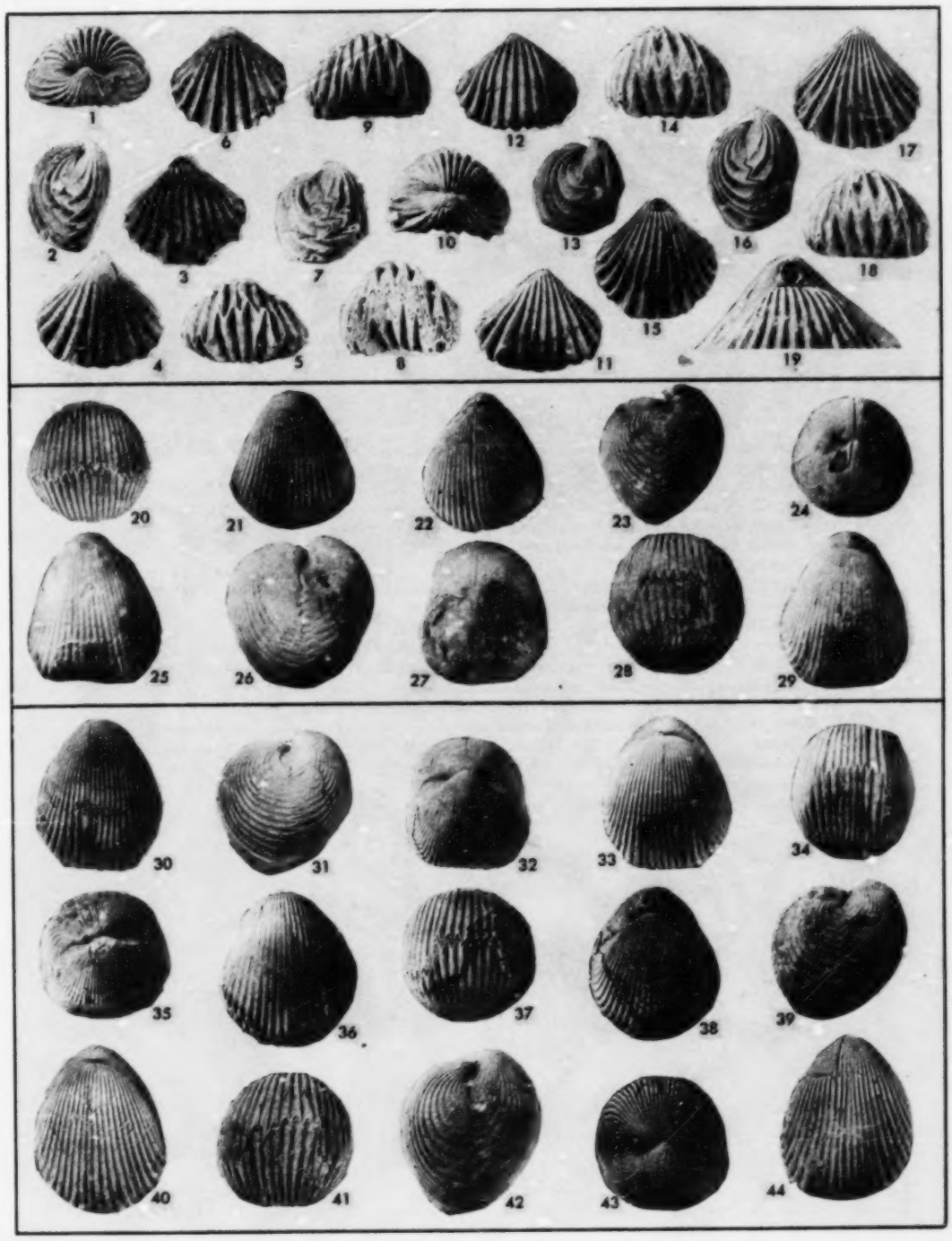
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PLATE 7

FIGURES 1–5.—*Daghanirhynchia sulcata*, new species: anterior, posterior, side, ventral, and dorsal views, ×1, holotype, USNM 380248. Locality S154.

FIGURES 6–21.—*Daghanirhynchia? triangulata*, new species: 6–10, posterior, dorsal, anterior, side and ventral views, ×1, paratype, USNM 380198; 11, beak of the preceding, ×2, showing rimmed deltidial plates; 12–16, anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380246; 17–21, side, anterior, ventral, posterior, and dorsal views, ×1, paratype, USNM 380380. Localities: 6–11, S1150; 12–16, S1444; 17–21, KK9-112.

FIGURES 22–26.—*Deltarhynchia compacta*, new species: anterior, posterior, ventral, side, and dorsal views, ×1, holotype, USNM 380240. Locality S1620.

FIGURES 27–43.—*Deltarhynchia triangulata*, new species: 27–31, posterior, anterior, dorsal, ventral and side views, ×1, paratype, USNM 380202; 32, beak of preceding showing deltidial plates with elevated margins, ×2; 33–37, posterior, anterior, ventral, side, and dorsal views, ×1, of the holotype, USNM 380369; 38–42, posterior, side, anterior, ventral, and dorsal views, ×1, paratype, USNM 380217a; 43, beak of preceding, ×2, showing dental plates with elevated rims. Localities: 27–37, S1503; 38–43, S1620.

FIGURES 44–53.—*Daghanirhynchia angulocostata*, new species: 44–48, side, posterior, anterior, ventral, and dorsal views, ×1, holotype, USNM 380201a; 49–52, posterior, anterior, side, and dorsal views, ×1, of an imperfect paratype, USNM 380440a; 53, beak of the preceding, ×2, showing basally thickened rimmed deltidial plates. Localities: 44–48, S1445; 49–53, S1463.

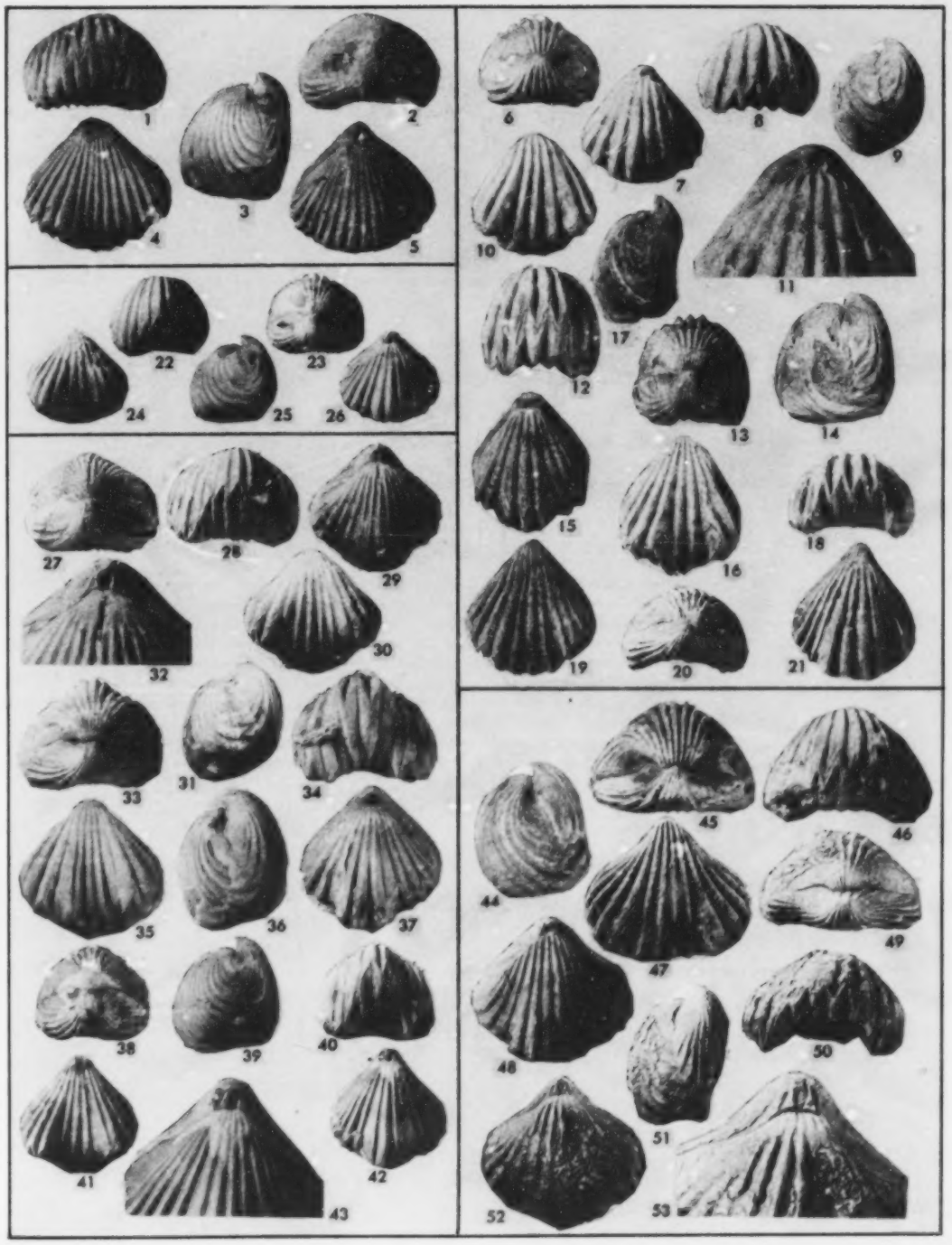
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PLATE 8

FIGURES 1–9.—*Echyrosia circularis*, new species: 1–5, anterior, posterior, side, dorsal, and ventral views, ×1, of an imperfect paratype, USNM 380539a; 6–8, side, dorsal, and ventral views, ×1, holotype, USNM 380539b; 9, anterior view of a broken specimen, ×1, paratype, USNM 380539c. Locality S1677.

FIGURES 10–15.—*Echyrosia costata*, new species: 10–14, posterior, ventral, anterior, side, and dorsal views, ×1, holotype, USNM 380195a; 15, beak of holotype, ×2, showing small foramen. Locality S1677.

FIGURES 16–20.—*Echyrosia costata*, new species: posterior, dorsal, side, ventral, and anterior views, ×1, paratype, USNM 380397. Locality S1250.

FIGURES 21–26.—*Echyrosia costata*, new species: 21–25, posterior, anterior, dorsal, side, and ventral views, ×1, paratype, USNM 380396; 26, beak of preceding, ×2, showing foramen and deltidial plates. Locality S1618.

FIGURES 27–49.—*Eurysites rotundus*, new species: 27–29, side, anterior, and dorsal views, ×1, paratype, USNM 380256; 30–34, ventral, posterior, dorsal, anterior, and side views, ×2, of preceding (note rimmed deltidial plates in figure 32); 35, dorsal view, ×1, holotype, USNM 380400; 36–40, dorsal, posterior, anterior, ventral, and side views, ×2, of holotype; 41–43, side, anterior, and dorsal, views, ×1, paratype, USNM 380252; 44, dorsal view, ×1, paratype, USNM 380401; 45–49, side, posterior, ventral, dorsal, and anterior views, ×2, of preceding paratype. Localities: 27–34, S1157; 35–40, KK8-30-35; 41–49, S1747.

FIGURES 50–59.—*Eurysites transversus*, new species: 50–54, side, dorsal, anterior, ventral, and posterior views, ×1, holotype, USNM 380232; 55–59, dorsal, anterior, side, posterior, and ventral views, ×2, holotype (note basally thickened deltidial plates in figure 55). Locality S1447.

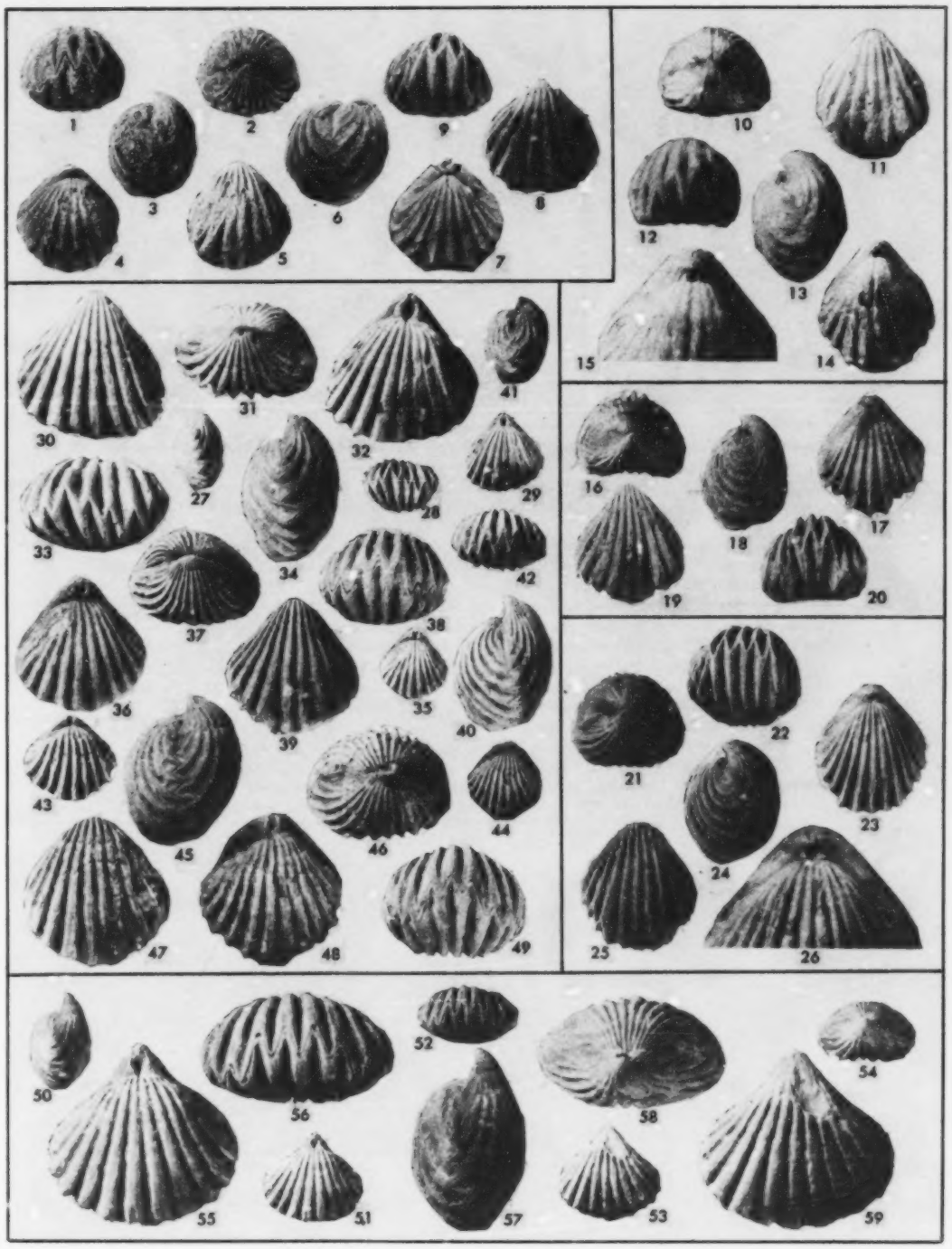
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PLATE 9

FIGURES 1–16.—*Eurysites transversa*, new species: 1–5, anterior, side, dorsal, posterior, and ventral views, ×1, paratype, USNM 380234; 6, dorsal view, ×1, paratype, USNM 380390; 7–11, anterior, posterior, side, ventral, and dorsal views, ×2, of the preceding paratype. 12–16, side, posterior, dorsal, anterior, and ventral views, ×1, of an unusually thick paratype, USNM 380366. Localities: 1–5, KK8-34; 6–11, S1742; 12–16, S1045.

FIGURES 17–23.—*Gibbirhynchia costata*, new species: 17, dorsal view, ×1, of the holotype, USNM 380395a; 18–22, anterior, posterior, side, ventral, and dorsal views, ×2, of the holotype; 23, side view, ×1, of a paratype, USNM 380395c. Locality KK6.

FIGURES 24–29.—*Gibbirhynchia pulcher*, new species: 24, dorsal view, ×1, of the holotype, USNM 380259; 25–29, anterior, dorsal, posterior, ventral, and side views, ×2, of the holotype. Locality KK7-35.

FIGURES 30–36.—*Gibbirhynchia mundula*, new species: 30–34, posterior, anterior, dorsal, side, and ventral views, ×1, holotype, USNM 380253; 35, 36, anterior and dorsal views, ×2, of the holotype. Locality S1501.

FIGURES 37–42.—*Gibbirhynchia parva*, new species: 37, dorsal view, ×1, holotype, USNM 380305a; 38–42, anterior, posterior, side, ventral, and dorsal views, ×2, of the holotype. Locality KK6.

FIGURES 43–55.—*Gibbirhynchia magna*, new species: 43–47, anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380233a; 48–50, side, anterior, and dorsal views, ×2, of the holotype; 51–55, posterior, ventral, anterior, side, and dorsal views, ×1, paratype, USNM 380233b. Locality KK6.

FIGURES 56–65.—*Gibbirhynchia rotundata*, new species: 56–60, ventral, dorsal, anterior, posterior, and side views, ×1, holotype, USNM 380251a; 61–65, dorsal, anterior, posterior, ventral, and side views, ×2, of the holotype. Locality KK7-35.

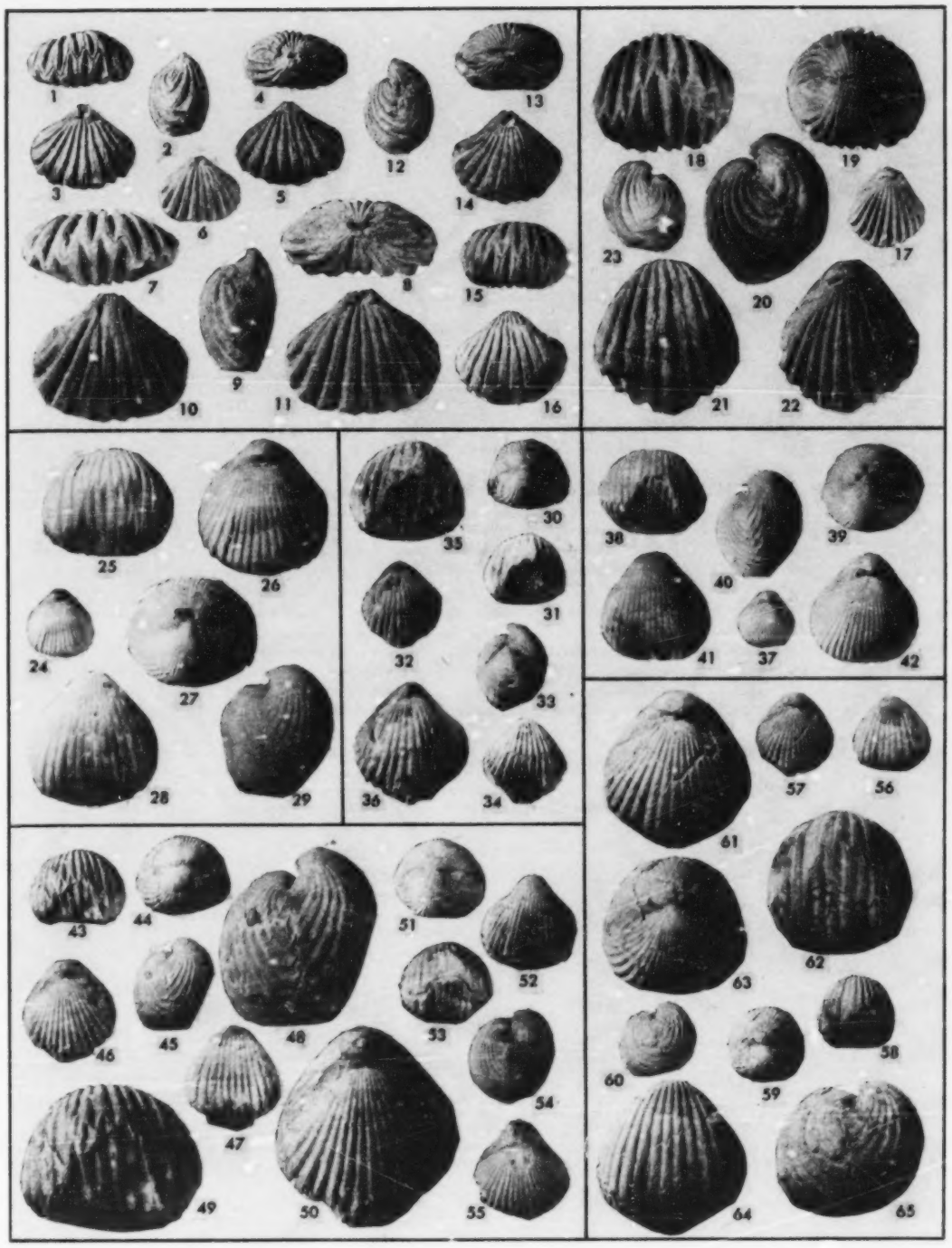
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PLATE 10

FIGURES 1–6.—*Gibbirhynchia subcircularis*, new species: 1, dorsal view, ×1, holotype, USNM 380266a; 2–6, posterior, anterior, side, ventral, and dorsal views, ×2, of the holotype. Locality S1618.

FIGURES 7–12.—*Globirhynchia? crassa*, new species: 7–11, side, anterior, posterior, ventral, and dorsal views, ×1, holotype, USNM 380255; 12, dorsal view, ×2, of the holotype. Locality S1617.

FIGURES 13–17.—*Burmirhynchia decorticata*, new species: posterior, anterior, side, dorsal, and ventral views, ×1, paratype, USNM 380534a. Locality S457.

FIGURES 18–30.—*Gibbirhynchia sphaerica*, new species: 18–22, side, posterior, ventral, anterior, and dorsal views, ×1, holotype, USNM 380238a; 23–25, anterior, dorsal, and side views, ×2, of the holotype; 26–30, dorsal, anterior, ventral, side, and posterior views, ×1, of paratype, USNM 380449a. Localities: 18–25, S1496; 26–30, KK9-15.5.

FIGURES 31–36.—*Globirhynchia? dubia*, new species: 31, dorsal view, ×1, of the holotype, USNM 380262; 32–36, anterior, posterior, side, ventral, and dorsal views, ×2, of the holotype. Locality S1679.

FIGURES 37–44, *Globirhynchia concinna*, new species: 37–41, posterior, anterior, ventral, side, and dorsal views, ×1 holotype, USNM 380243a; 42–44, anterior, side, and dorsal views, ×2, of the holotype. Locality S1244.

FIGURES 45–55, *Globirhynchia subtriangulata*, new species: 45–49, posterior, anterior, side, dorsal, and ventral views, ×1, paratype, USNM 380254; 50, dorsal view, ×2, of the paratype; 51–55, anterior, side, posterior, dorsal, and ventral views, ×1, of a paratype, USNM 380503. Localities: 45–50, S1179; 51–55, KK9-20.5.

FIGURES 56–71, *Kallirhynchia arabica*, new species: 56–60, anterior, side, posterior, dorsal, and ventral views, ×1, paratype, USNM 380365a; 61–65, side, anterior, dorsal, ventral, and posterior views, ×1, of a paratype, USNM 380446a; 66–70, anterior, posterior, ventral, dorsal, and side views, ×1, holotype, USNM 380239a; 71, beak of the holotype, ×2. Localities: 56–65, S1674; 66–71, S1191.

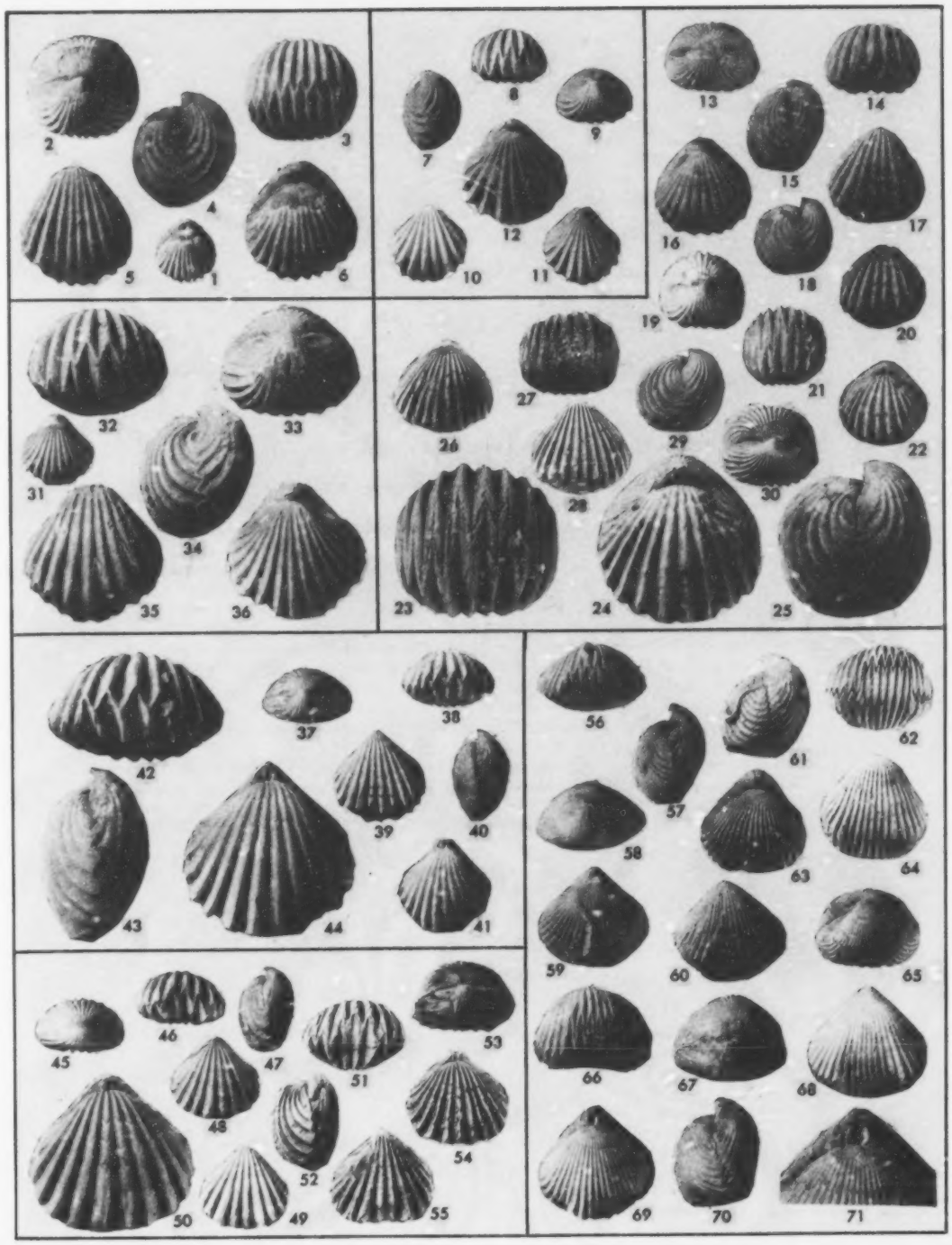
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PLATE 11

FIGURES 1–5.—*Globirhynchia triangulata*, new species: anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380196a. Locality S1618.

FIGURES 6–10.—*Kallirhynchia orbicularis*, new species: posterior, anterior, side, dorsal, and ventral views, ×1, holotype, USNM 380522a. Locality S1191.

FIGURES 11–15.—*Daghanirhynchia? triangulata*, new species: anterior, posterior, side, ventral, and dorsal views, ×1, paratype, USNM 380250a. Locality KK9-117.

FIGURES 16–21.—*Daghanirhynchia angulocostata*, new species: 16–20, side, posterior, anterior, dorsal, and ventral views, ×1, paratype, USNM 380220; 21, dorsal view, ×2, same paratype. Locality S1644.

FIGURES 22–26.—*Kallirhynchia dispar*, new species: anterior, posterior, side, ventral, and dorsal views, ×1, holotype, USNM 380229a. Locality S1738.

FIGURES 27–36.—*Kutchirhynchia arabica*, new species: 27–31, posterior, anterior, side, ventral, and dorsal views, ×1, holotype, USNM 380271a; 32–36, side, anterior, posterior, ventral, and dorsal views, ×1, paratype, USNM 380271b. Locality S1191.

FIGURES 37–42, *Nastosia coangustata*, new species: 37–41, dorsal, side, ventral, posterior, and anterior views, ×1, holotype, USNM 380199b; 42, posterior view, ×2, showing closely spaced parallel dental plates, paratype, USNM 380199a. Locality S1679.

FIGURES 43–55.—*Lirellarina costellata*, new species: 43–47, posterior, anterior, side, ventral, and dorsal views, ×1, holotype, USNM 380241c; 55, ventral view, ×2, of the holotype; 48, anterior view, ×2, showing costellae, imperfect paratype, USNM 380636; 49–52, dorsal, side, ventral, and posterior views, ×1, paratype, USNM 380241b; 53, 54, dorsal and side views, ×2, of the same paratype, USNM 38021b. Locality S1677.

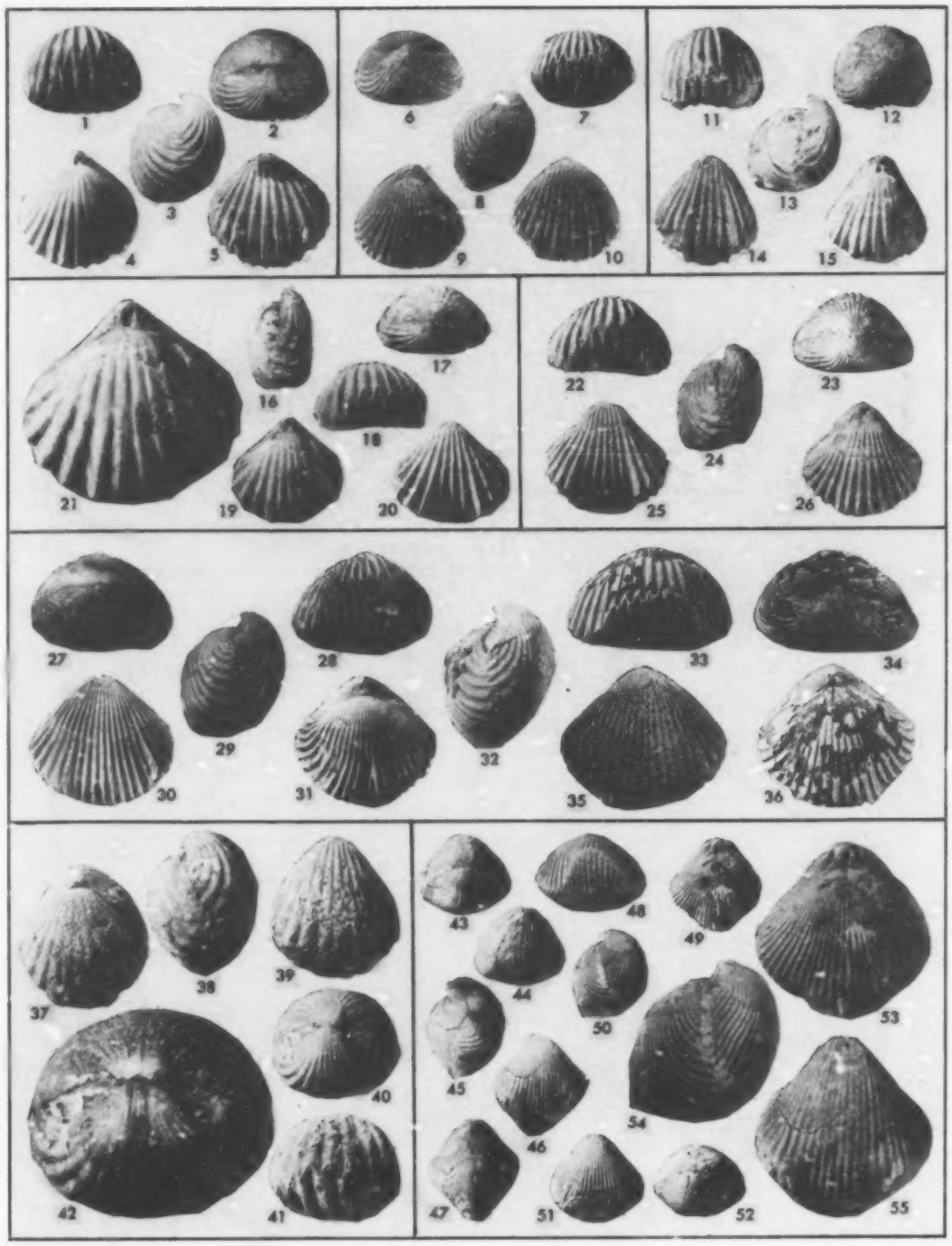
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PLATE 12

FIGURES 1–5.—*Nastosia coangustata*, new species: posterior, anterior, side, ventral, and dorsal views, ×1, paratype, USNM 380279. Locality S1409.

FIGURES 6–10.—*Pycnoria compacta*, new species: posterior, anterior, side, ventral and dorsal views, ×1, holotype, USNM 380453. Locality Astro 61.

FIGURES 11–36.—*Pycnoria magna*, new species: anterior, ventral, posterior, dorsal, and side views, ×1, of an unusually large specimen, paratype, USNM 380565a. Locality KK9-112.

FIGURES 16–36.—*Pycnoria magna*, new species: 16–20, anterior, posterior, side, ventral, and dorsal views, ×1, paratype, USNM 380378; 21–25, side, ventral, anterior, dorsal, and posterior views, ×1, small paratype, USNM 380216; 26–30, anterior, posterior, side, dorsal, and ventral views, ×1, paratype, USNM 380207; 31–35, anterior, dorsal, posterior, side, and ventral views, ×1, holotype, USNM 380215a; 36, beak of the holotype showing rimmed deltidial plates, ×2. Localities: 16–20, KK9-22.5; 21–25, S1425; 26–30, S1755; 31–36, S1444.

FIGURES 37–41.—*Somalirhynchia africana* Weir: ventral, anterior, dorsal, side, and posterior views, ×1, large hypotype, USNM 380381. Locality S1048.

FIGURES 42–46.—*Torquirhynchia? parva*, new species: posterior, anterior, ventral, dorsal, and side views, ×1, holotype, USNM 380281. Locality KK10-37.5.

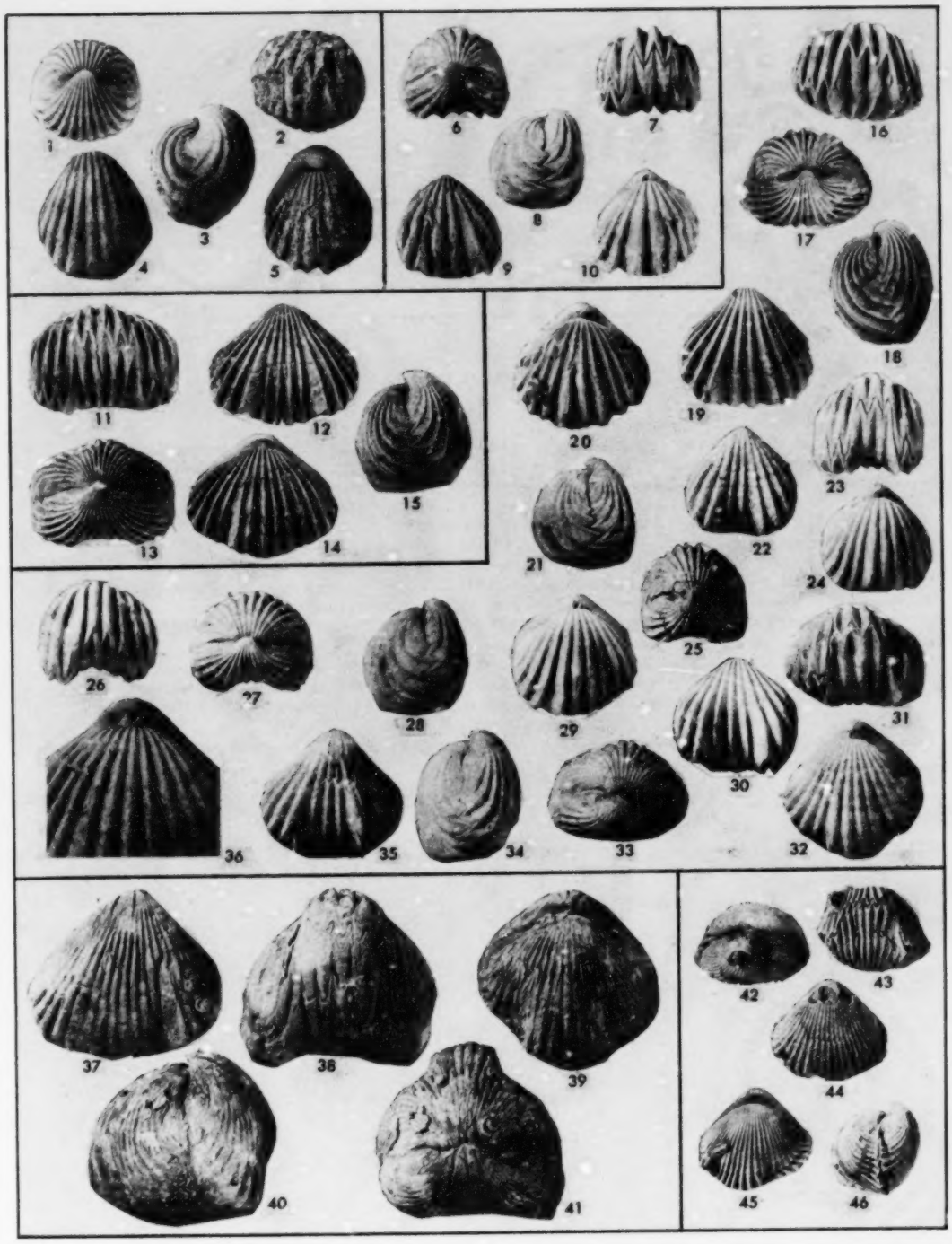
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PLATE 13

FIGURES 1–13.—*Schizoria dividicostata*, new species: 1–3, anterior, dorsal, and side views, ×1, holotype, USNM 380249a; 4–8, ventral, posterior, side, anterior, and dorsal views, ×2, of the holotype. 9–13, dorsal, ventral, anterior, posterior, and side views, ×1, paratype, USNM 380391. Locality S1677.

FIGURES 14–18.—*Schizoria intercalata*, new species: 14, dorsal view, ×1, holotype, USNM 380391; 15–18, dorsal, side, anterior, and ventral views, ×2, of the holotype. Locality S1409.

FIGURES 19–24.—*Schizoria intermedia*, new species: 19, dorsal view, ×1, holotype, USNM 380388a; 20–24, posterior, dorsal, side, ventral, and anterior views, ×2, of the holotype. Locality S1677.

FIGURES 25–30.—*Schizoria rotundata*, new species: 25, dorsal view, ×1, holotype, USNM 380389; 26–30, ventral, side, posterior, dorsal, and anterior views, ×2, of the holotype. Locality S1661.

FIGURES 31–36.—*Schizoria* species 2: 31, dorsal view, ×1, of specimen, USNM 380393a; 32–36, dorsal, ventral, side, posterior, and anterior views, ×2, of the same specimen, USNM 380393a. Locality S997.

FIGURES 37–45.—*Schizoria costellata*, new species: 37–41, ventral, posterior, side, dorsal, and anterior views, ×1, holotype, USNM 380242a; 42–44, dorsal, anterior, and side views, ×2, of the holotype; 45, dorsal view, ×3, showing rimmed deltidial plates and intercalated costellae, of an imperfect paratype, USNM 380242b. Locality S1409.

FIGURES 46–50.—*Somalirhynchia prearabica*, new species: side, ventral, anterior, dorsal, and posterior views, ×1, holotype, USNM 380375. Locality S1675.

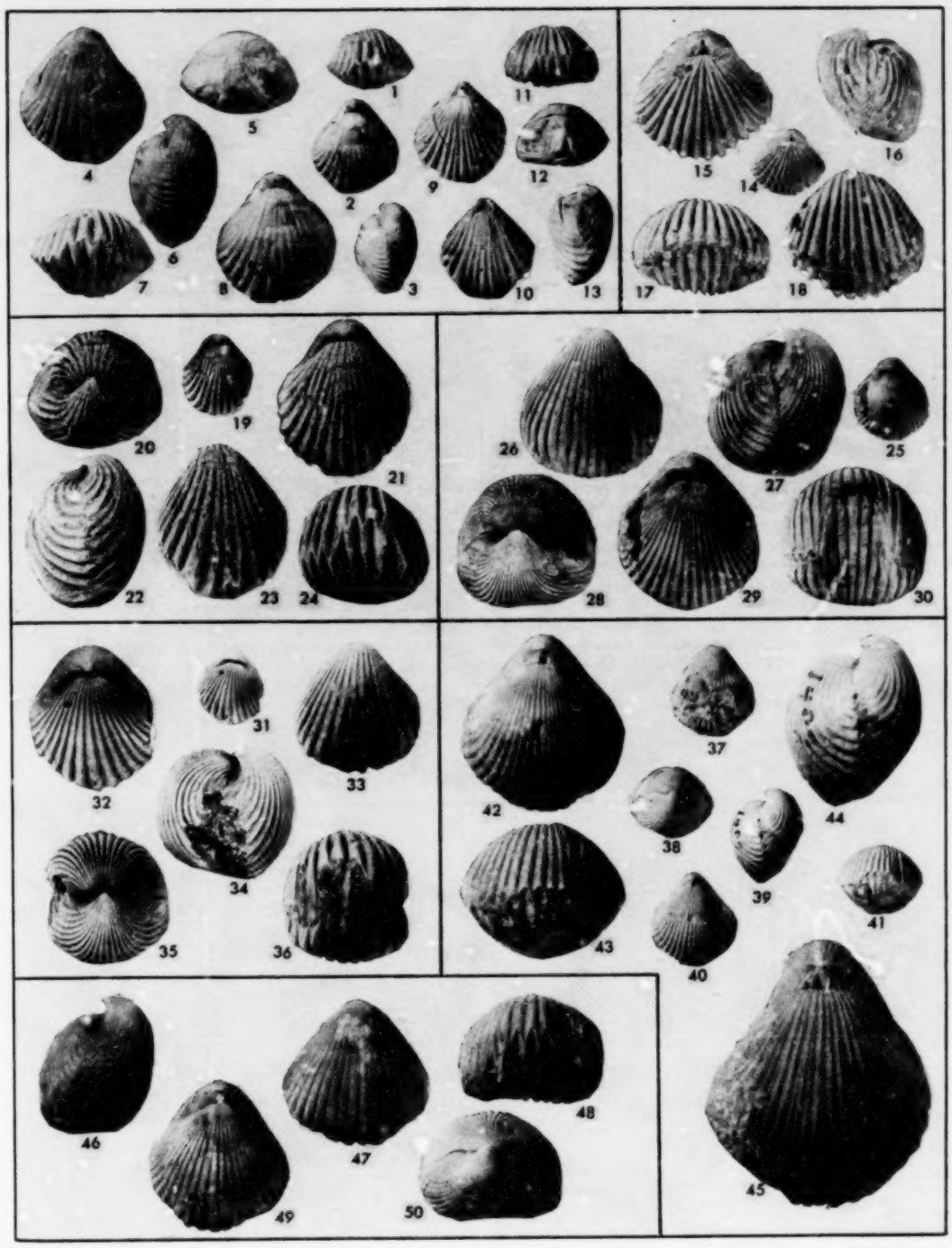
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PLATE 14

FIGURES 1–5.—*Somalirhynchia arabica* species: posterior, side, ventral, dorsal, and anterior views, ×1, holotype, USNM 380206. Locality KK10-25.

FIGURE 6.—*Schizoria* species 1: dorsal view, ×1, USNM 380261. Locality S1409.

FIGURES 7–11.—*Sphenorhynchia? angulata*, new species: anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380270. Locality S1422.

FIGURES 12–16.—*Somalirhynchia deficiens*, new species: ventral, anterior, side, posterior, and dorsal views, ×1, holotype, USNM 380372. Locality S1715.

FIGURES 17–27.—*Schizoria elongata*, new species: 17–21, posterior, dorsal, side, ventral, and anterior views, ×2, holotype, USNM 380260b; 22, dorsal view, ×1, paratype, USNM 380260a; 23–27, ventral, posterior, anterior, side, and dorsal views, ×2, of the preceding paratype. Locality S1409.

FIGURES 28–46.—*Schizoria secta*, new species: 28–32, anterior, dorsal, side, ventral, and posterior views, ×1, paratype, USNM 380231b; 33–36, dorsal, posterior, side, and anterior views, ×2, of the preceding paratype; 37–41, anterior, side, ventral, dorsal, and posterior views, ×1, holotype, USNM 380231a; 42–46, ventral, posterior, anterior, side, and ventral views, ×2, of the holotype. Locality S1057.

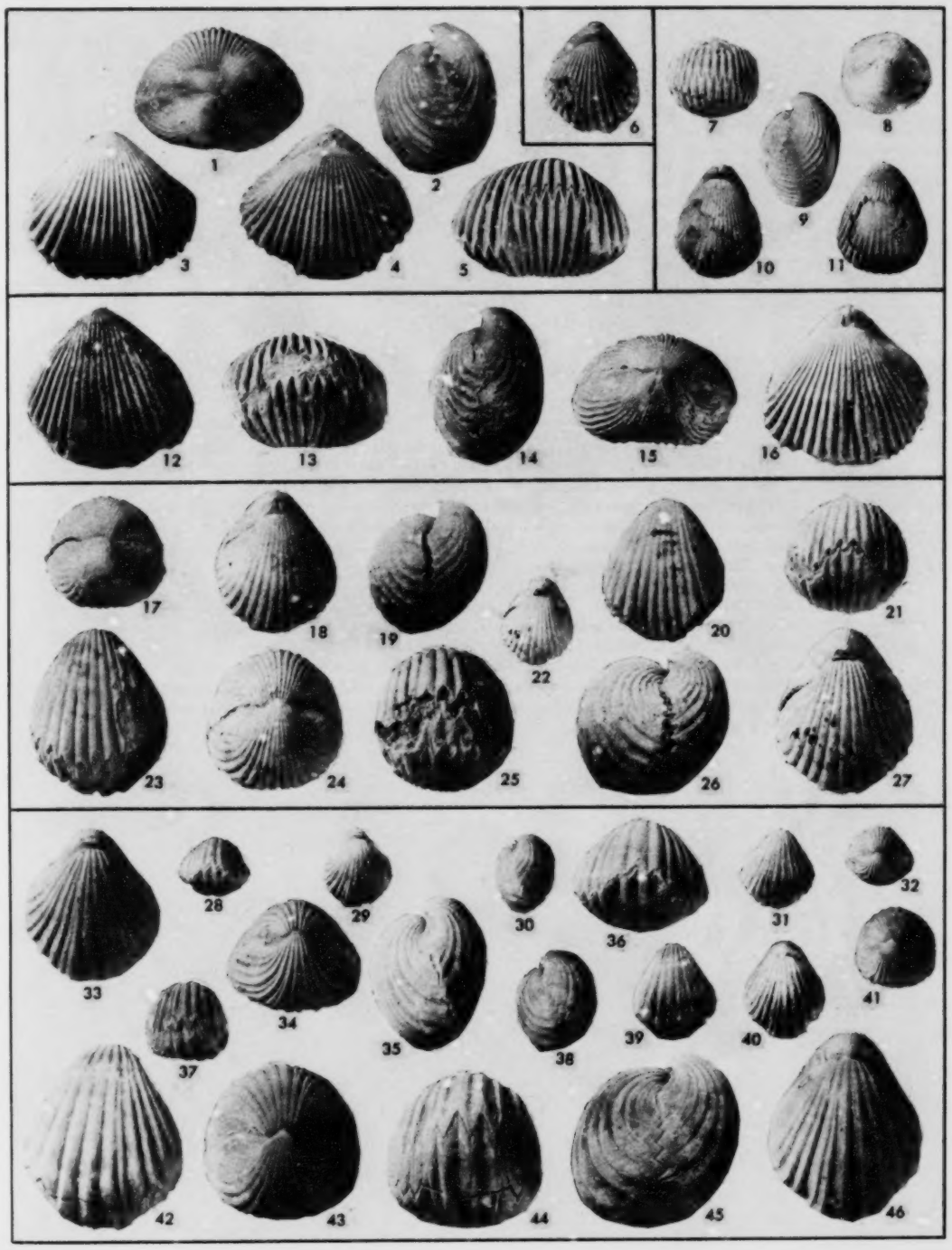
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PLATE 15

FIGURES 1–23.—*Somalirhynchia somalica* (Dacqué): 1–5, anterior, posterior, side, dorsal, and ventral views, ×1, hypotype, USNM 380516; 6–10, anterior, side, dorsal, posterior, and ventral views, ×1, of a large hypotype, USNM 380286a; 11–15, side, posterior, anterior, ventral, and dorsal views, ×1, narrow hypotype, USNM 380377; 16, beak of the preceding, ×2, showing deltidial plates with raised margins; 17–21, ventral, dorsal, anterior, side, and posterior views, ×1, of a small hypotype, USNM 380344; 22, 23, interior, ×2, showing crura, teeth, and deltidial plates, hypotype, USNM 380634a,b. Localities: 1–10, S154; 11–16, S1458; 17–21, KK10-33–34; 22, 23, KK10-37.5.

FIGURE 24.—*Schizoria costellata*, new species: view of beak showing teeth and deltidial plates, ×3, paratype, USNM 380301. Locality S1057.

FIGURES 25–35.—*Somalirhynchia arabica*, new species: 25–29, anterior, ventral, posterior, side, and dorsal views, ×1, paratype, USNM 380371c; 30, 31, two views of the dorsal interior showing crura, ×2, paratype USNM 380298; 32, ventral valve of preceding showing dental plates and teeth, ×2, paratype, USNM 380298; 33, interior of a paratype showing crura and median septum, ×2, paratype, USNM 380299; 34, Exterior, ×1, of an imperfect silicified paratype, USNM 380514; 35, interior of the preceding paratype, ×3, showing septalium, median septum and one crus. Locality. KK10-25.5.

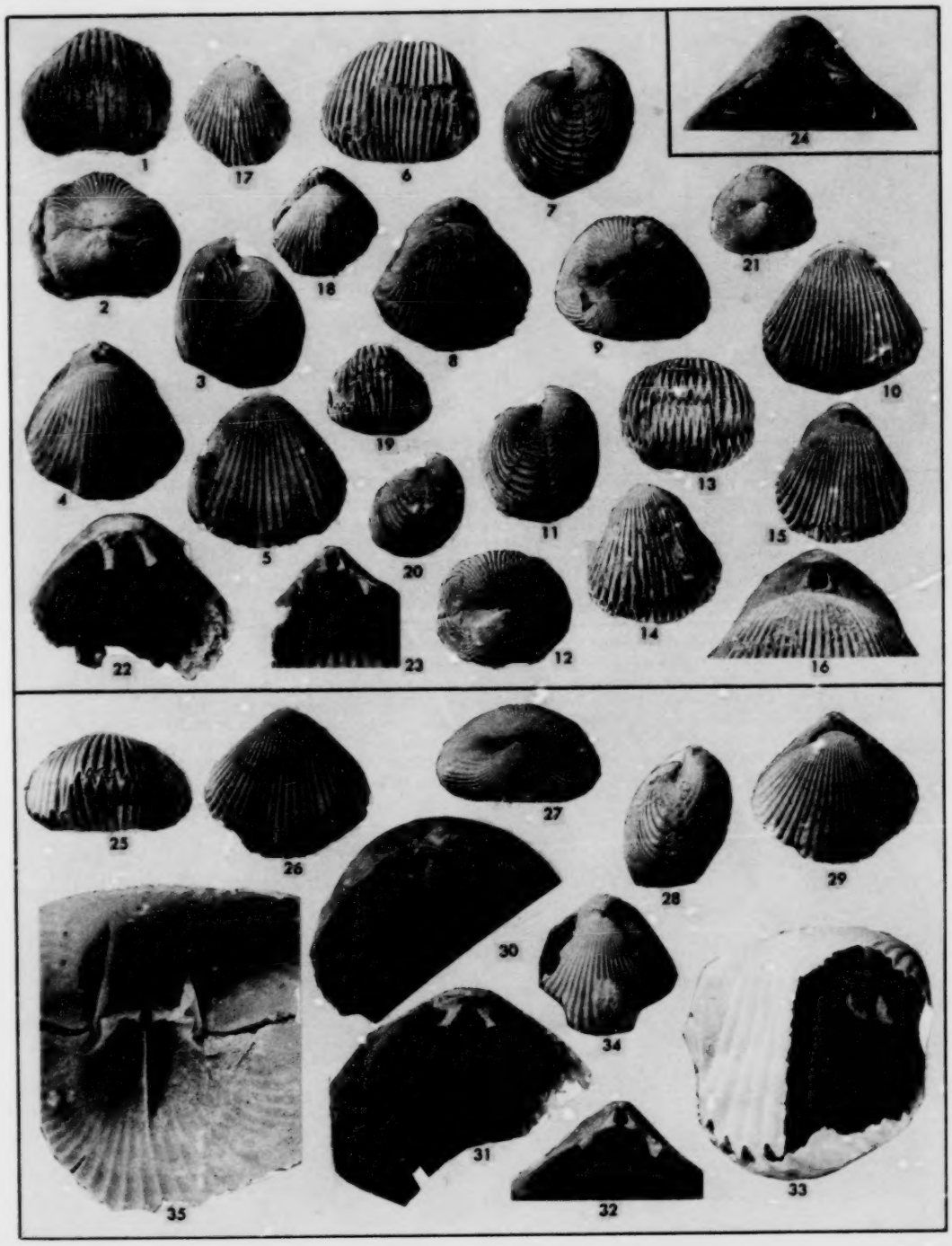
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PLATE 16

FIGURES 1–10.—*Strongyloria circularis*, new species: 1–3, ventral, anterior, and dorsal views, ×1, of a large paratype, USNM 380384a; 4, side view, ×1, of a paratype, USNM 380384b; 5, beak of the preceding paratype, ×2, showing rimmed deltidial plates; 6–10, side, posterior, anterior, ventral, and dorsal views, ×1, of the holotype, USNM 380200a. Localities: 1–5, S1167; 6–10, S1170.

FIGURES 11–15.—*Strongyloria subelliptica*, new species: 11–14, anterior, ventral, side, and dorsal views, ×1, holotype, USNM 380218; 15, beak of the holotype, ×2, showing foramen and deltidial plates. Locality KK8-33.5.

FIGURES 16–20.—*Torquirhynchia? convexa*, new species: posterior, side, anterior, dorsal, and ventral views, ×1, holotype, USNM 380275. Locality S154.

FIGURES 21–32.—*Sphenorhynchia varicostata*, new species: 21–25, anterior, posterior, dorsal, ventral, and side views, ×1, of a finely costate paratype, USNM 380228a; 26, beak of the preceding paratype ×2; 27–31, side, anterior, ventral, dorsal, and posterior views, ×1, of a finely costate paratype, USNM 380221a; 32, beak of the preceding, ×2. Localities: 21–26, S1503; 27–32, S1485.

FIGURES 33–45.—*Sphenorhynchia varicostata*, new species: 33–37, dorsal, anterior, side, posterior, and ventral views, ×1, holotype, USNM 380197; 38–42, ventral, anterior, posterior, dorsal, and side views, ×1, paratype, USNM 380623a; 43, beak of the preceding showing deltidial plates, ×2; 44, ventral view of a specimen exhibiting the crural plates, ×1, paratype, USNM 380439; 45, section along the plane of articulation, ×2, of a paratype, USNM 380447. Localities: 33–37, 45, S1485; 38–44, S1617.

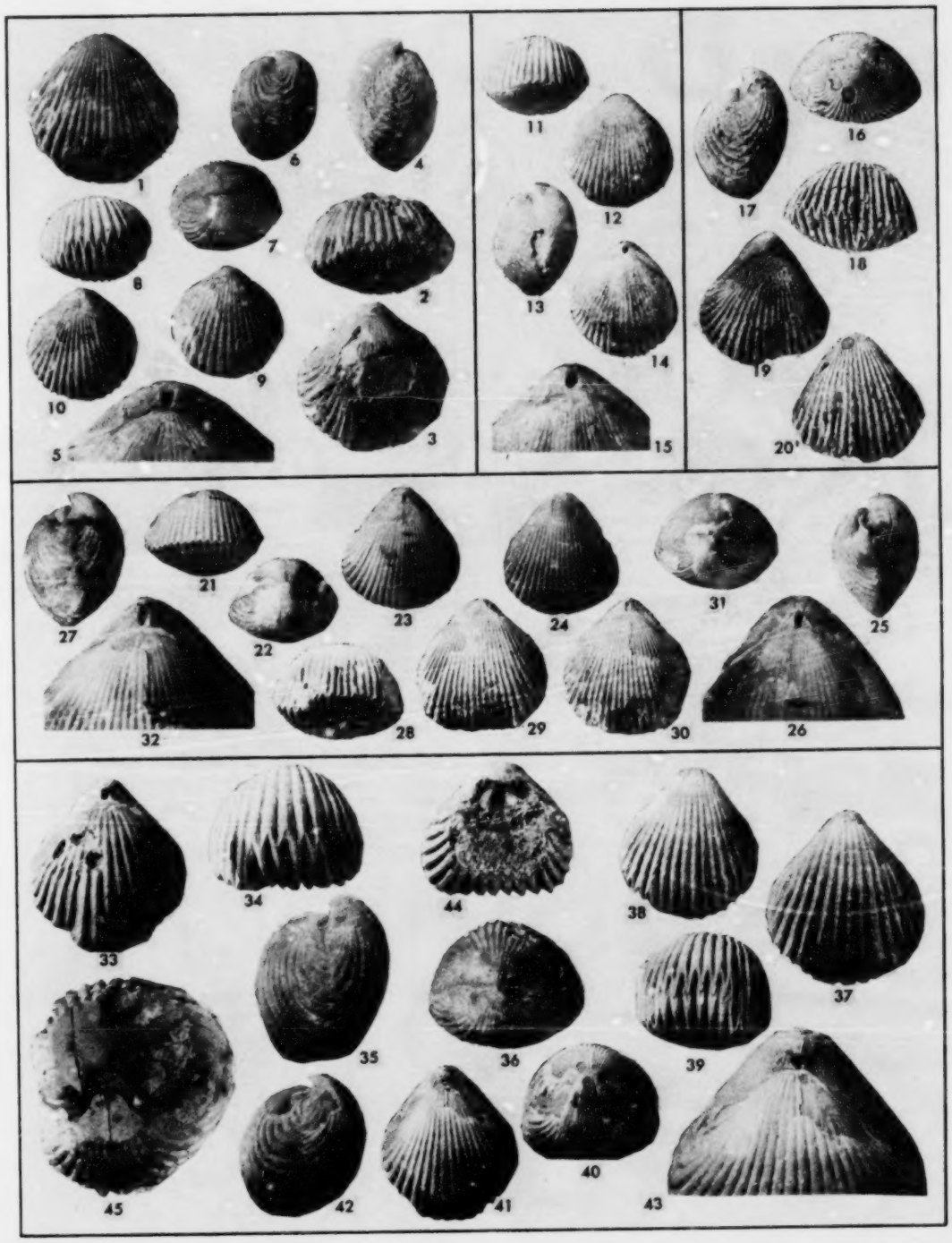
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PLATE 17

FIGURES 1–11.—*Eurysites rotundus*, new species: 1, dorsal view, ×1, paratype, USNM 380359a; 2–6, anterior, ventral, side, posterior, and dorsal views, ×2, of the preceding paratype; 7–11, ventral, side, posterior, dorsal, and anterior views, ×1, paratype, USNM 380399b. Localities: 1–6, S1440; 7–11, S1503.

FIGURES 12.—*Eurysites transversus*, new species: dorsal view, ×3, showing the concentric fila undulating over the costae, paratype, USNM 380450. Locality S1460.

FIGURES 13–17.—*Somalirhynchia somalica* (Dacqué): dorsal, anterior, side, posterior, and ventral views, ×1, hypotype, USNM 380273. Locality S1488.

FIGURES 18–22. Rhynchonellacean genus and species undetermined. Posterior, anterior, ventral, side, and dorsal views, ×1, of the single specimen, USNM 380635. Locality S1675.

FIGURES 23–27.—*Somalirhynchia somalica* (Dacqué): anterior, posterior, ventral, side, and dorsal views, ×1, of a narrow hypotype, USNM 380445. Locality S1458.

FIGURES 28–37.—*Globirhynchia subtriangulata*, new species: 28–32, posterior, anterior, side, dorsal, and ventral views, ×1, paratype, USNM 380502; 33–37, side, posterior, dorsal, anterior, and ventral views, ×1, holotype, USNM 380448a. Localities: 28–32, KK9-21; 33–37, KK9-52.5.

FIGURES 38–42.—*Nastosia? convexa*, new species: posterior, anterior, dorsal, side, and ventral views, ×1, holotype, USNM 380398. Locality S1409.

FIGURES 43–45.—*Kallirhynchia obesa*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380564. Locality KK8A-58.

FIGURES 46–51.—*Echyrosia expansa*, new species: 46–50, anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380563a; 51, dorsal view, ×1, paratype, USNM 380563b. Locality S1677.

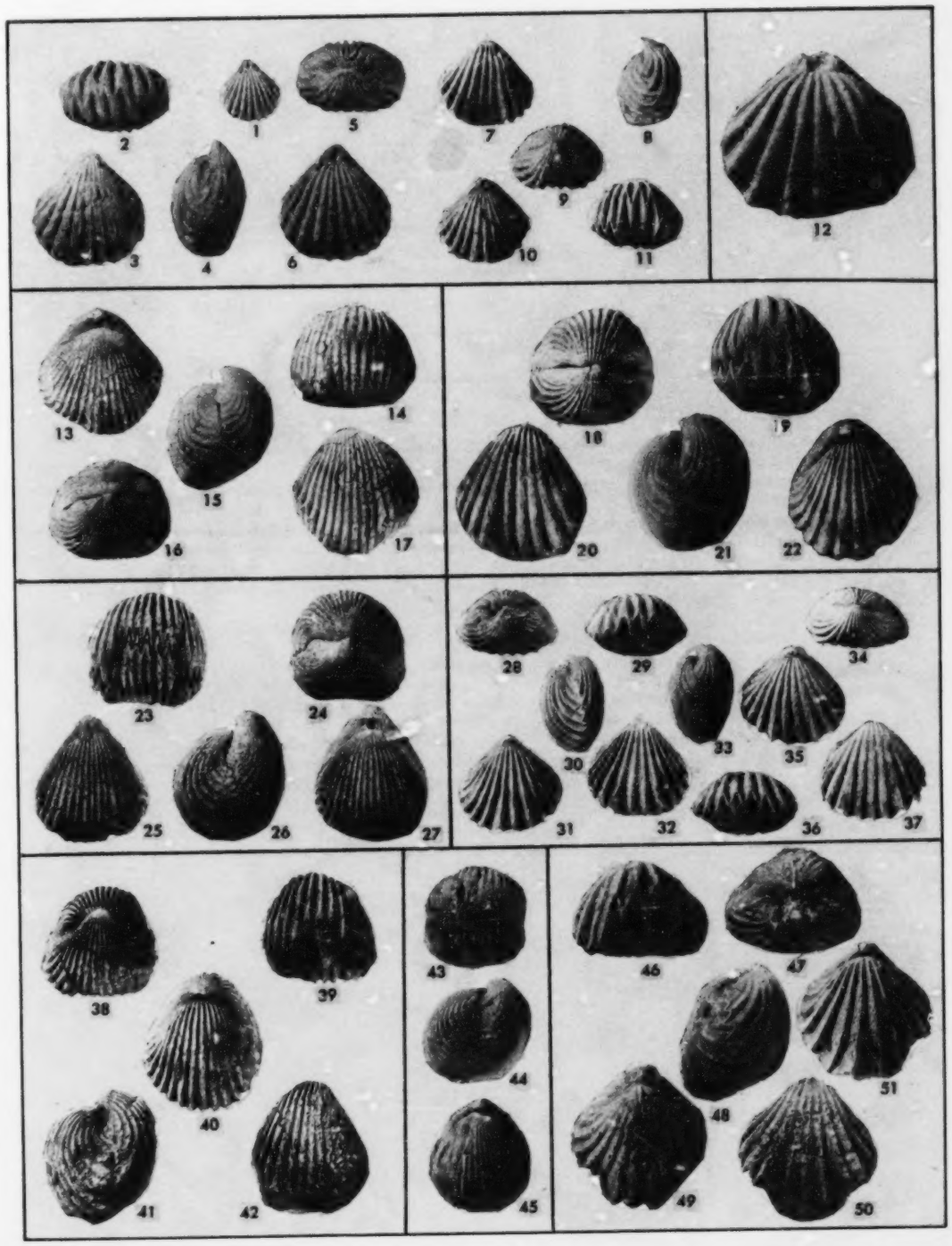
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PLATE 18

FIGURES 1–6.—*Apothyris* species: 1, dorsal view, ×1, USNM 400921; 2–6, dorsal, posterior, ventral, anterior, and side views, ×2. Locality S989.

FIGURE 7.—*Zeilleria* species 2: dorsal view, ×1, of a decorticated specimen showing median septum, USNM 380562. Locality S1175.

FIGURES 8–10.—*Sphriganaria* species 2: side, anterior, and dorsal views, ×1, USNM 380640. Locality S149.

FIGURES 11–15.—*Burmirhynchia decorticata*, new species: posterior, anterior, side, ventral, and dorsal views, ×1, paratype, USNM 402741. Locality KK9-22.5.

FIGURES 16–20.—*Colpotoria plicatilis*, new species: anterior, side, posterior, ventral, and dorsal views, ×1, paratype, USNM 380611a. Locality S743.

FIGURES 21–25.—*Cynatorhynchia? singularis*, new species: posterior, anterior, side, dorsal, and ventral views, ×1, paratype, USNM 380614. Locality S1506.

FIGURES 26–36.—*Pycnoria magna*, new species: 26–30, anterior, side, ventral, posterior, and dorsal views, ×1, paratype, USNM 380604; 31–35, side, posterior, anterior, ventral, and dorsal views, ×1, of an imperfect paratype, USNM 380603. 36, beak of the preceding paratype, ×2, showing deltidial plates with thickened rims. Localities: 26–30, KK9-54; 31–36, KK9-112.

FIGURES 37–45.—*Heteromychus magnificus*, new species: 37–40, anterior, dorsal, side, and posterior views, ×1, of a young paratype, USNM 380693a; 41–45, posterior, ventral, side, dorsal, and anterior views ×1, holotype, USNM 380576. Localities: 37–40, KK9-112; 41–45, S1296.

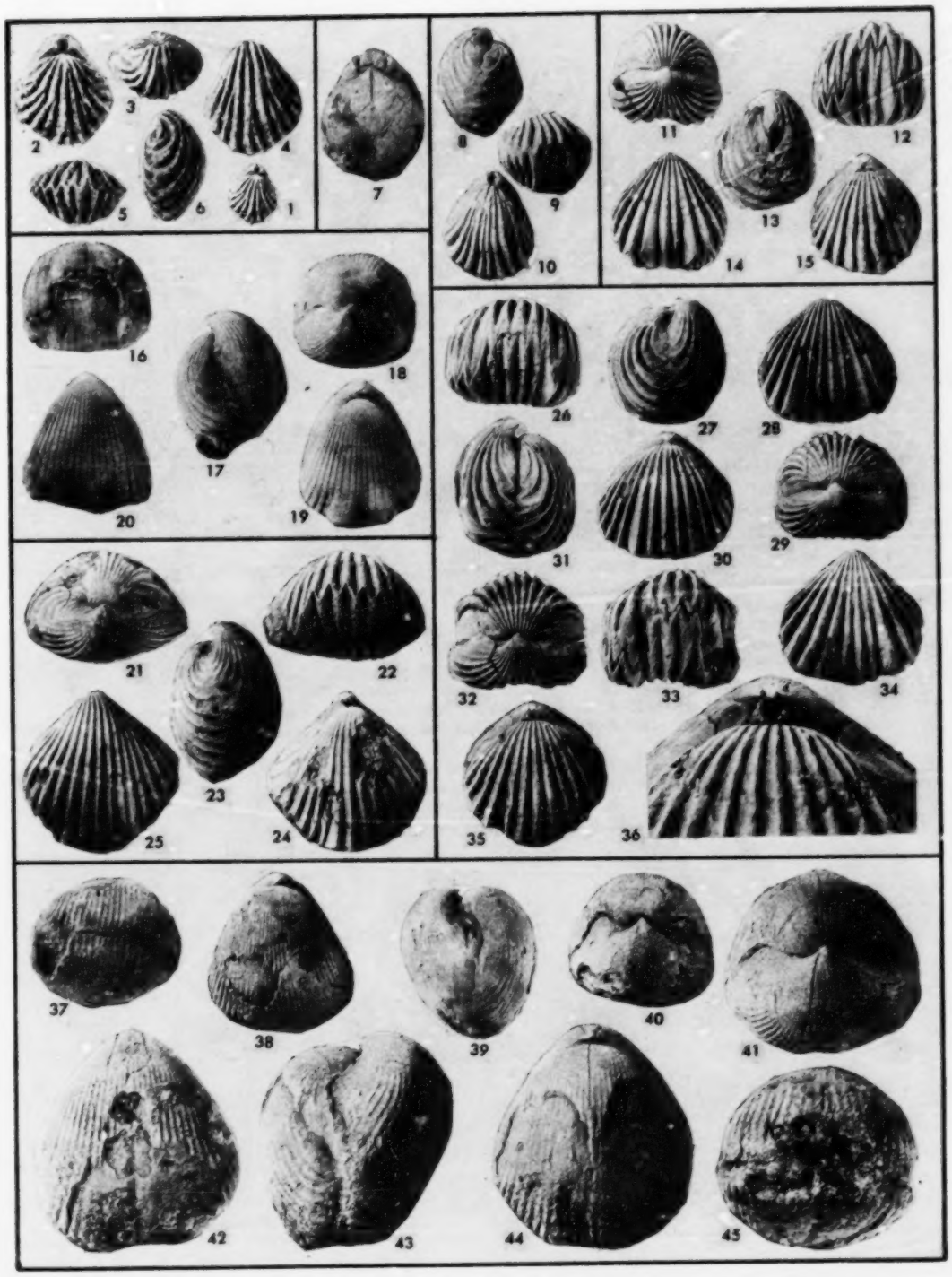
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PLATE 19

FIGURES 1–13.—*Calyptoria extensa*, new species: 1–5, ventral, anterior, side, dorsal, and posterior views, ×1, paratype, USNM 380322a; 6, side view, ×2, of preceding paratype; 7–11, anterior, side, dorsal, posterior, and ventral views, ×1, of the holotype, USNM 380323a; 12, side view, ×2, of the holotype; 13, side view of a specimen sectioned to show the spire, ×2, paratype, USNM 380323g. Localities: 1–6, S1034; 7–13, S1030.

FIGURE 14.—*Liospiriferina rostrata* (Schlotheim): views, ×1 and ×2, showing the deltidial cover and fine, hair-like spines, USNM 380469. Middle Lias, Les Granges, south-southeast of Argenton, Indre, France.

FIGURES 15–19.—*Spiriferina* species 2: posterior, dorsal, anterior, side, and ventral views, ×1, USNM 380624. Locality S1030.

FIGURES 20–24.—*Spiriferina* species 3: posterior, ventral, dorsal, side, and anterior views, ×1, USNM 380348. Locality S1175.

FIGURES 25–29.—*Spiriferina* species 1: ventral, dorsal, anterior, side, and posterior views, ×1, USNM 380350. Locality S1030.

FIGURES 30–35.—*Liospiriferina vulgata*, new species: 30–34, dorsal, anterior, side, posterior, and ventral views, ×1, holotype, USNM 380328; 35, enlargement, ×3, of patch on right side of holotype showing small spine bases. Locality S1034.

FIGURES 36–52.—*Liospiriferina obesa*, new species: 36–40, posterior, ventral, dorsal, side, and anterior views, ×1, paratype, USNM 380521a; 41–45, posterior, anterior, side, ventral, and dorsal views, ×1, of a small paratype, USNM 380347a; 46, 47, dorsal view, ×1, and beak, ×3, showing deltidial cover, paratype, USNM 380347b; 48–52, anterior, dorsal, side, posterior, and ventral views, ×1, holotype, USNM 380325. Localities: 36–40, 48–52, S1175; 41–47, S989.

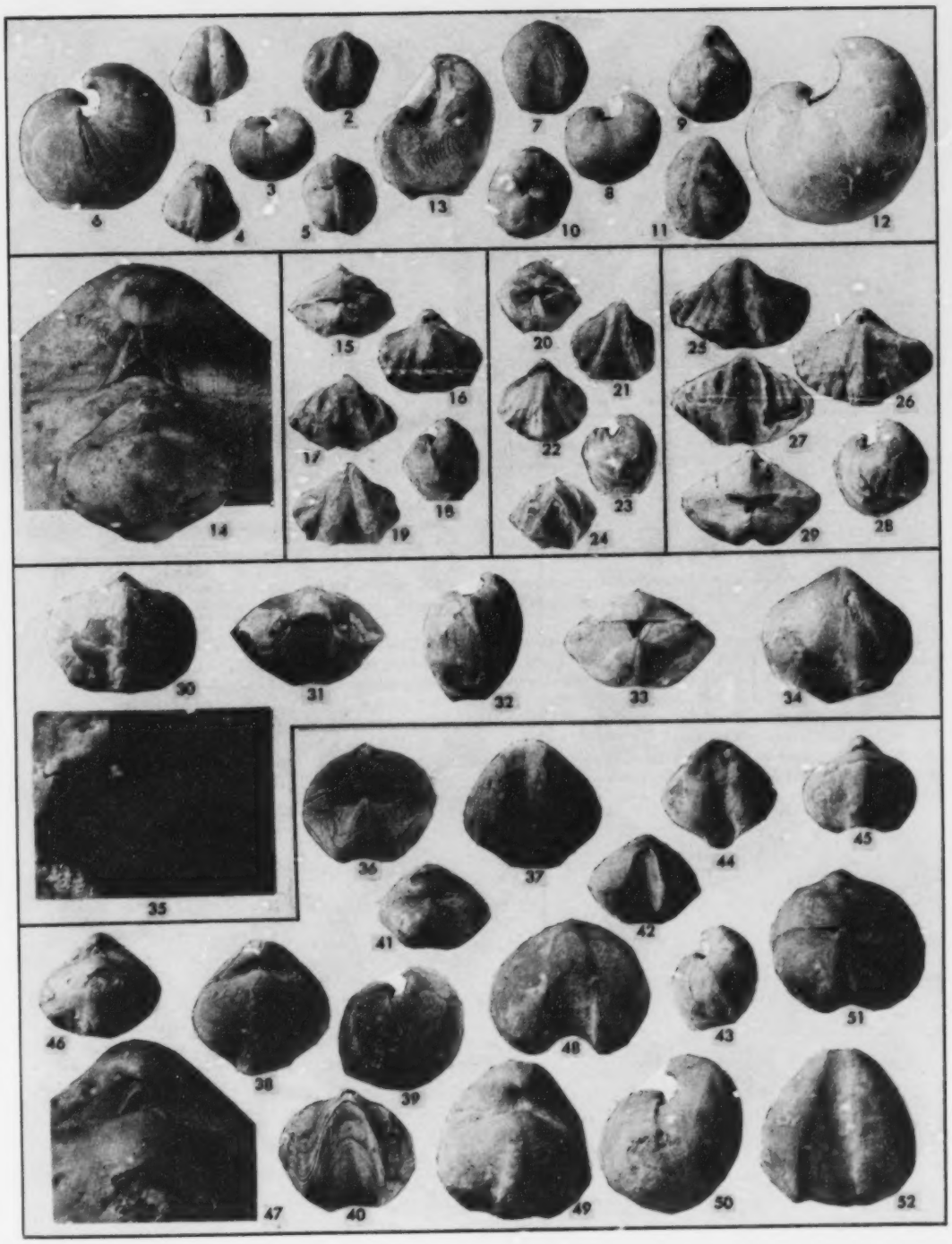
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PLATE 20

FIGURES 1–5.—*Apatecosia inornata*, new species: 1–3, anterior, dorsal, and side views, ×1, holotype, USNM 380410; 4, dorsal view of silicified paratype, USNM 380297; 5, interior of the preceding paratype, ×2. Locality S459.

FIGURES 6–10.—*Apatecosia varians*, new species: 6–8, side, dorsal and anterior views, ×1, holotype, USNM 380480a; 9, 10, partial side and ventral views, ×2, of the loop of a paratype, USNM 380480b. Locality S154.

FIGURES 11–13.—*Arabicella? costata*, new species: dorsal, anterior and side views, ×1, holotype, USNM 380426. Locality S1146.

FIGURES 14–19.—*Ectyphoria inflata*, new species: 14–16, dorsal, anterior, and side views, ×1, holotype, USNM 380413; 17–19, anterior, side, and dorsal views, ×1, paratype, USNM 380405. Localities: 14–16, S1615; 17–19, S1148.

FIGURES 20–26.—*Arabatia concava*, new species: 20–23, ventral, side, dorsal, and anterior views, ×1, holotype, USNM 380462a; 24, dorsal view, ×1, of a decorticated paratype showing elongate adductor scars, USNM 380532; 25, 26, partial side and ventral views, ×2, of a young excavated paratype showing imperfect loop, USNM 380462b. Locality S293.

FIGURES 27–29.—*Ectyphoria inflata*, new species: side, anterior and dorsal views, ×1, paratype, USNM 380431. Locality KK9-96–97.

FIGURES 30–32.—*Arabicella ovalis*, new species: anterior, dorsal, and side views, ×1, paratype, USNM 380425a. Locality KK9-112.

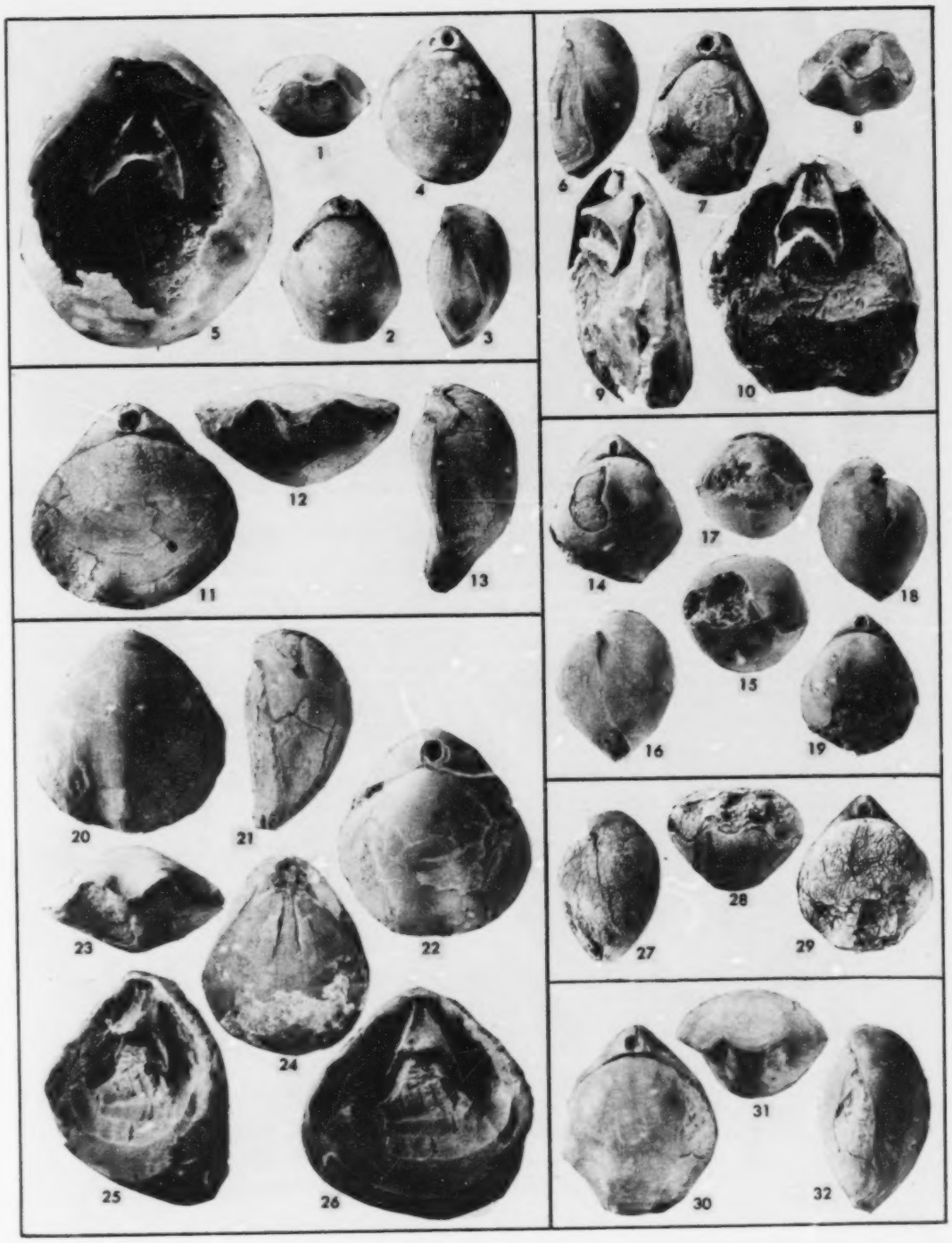
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PLATE 21

FIGURES 1–9.—*Arabicella ovalis*, new species: 1–3, dorsal, side, and anterior views, ×1, of a young paratype, USNM 380543; 4–6, anterior, dorsal, and side views, ×1, holotype, USNM 380292; 7, imperfect loop, ×1, paratype, USNM 380493; 8, 9, ventral and partial side views, ×2, of the loop of the preceding paratype. Localities: 1–3, S1009; 4–6, KK9-97-98; 7–9, S1296.

FIGURES 10–12.—*Arabicella subplana*, new species: anterior, dorsal, and side views, ×1, paratype, USNM 380456. Locality KK9-112.

FIGURES 13–32.—*Arabicella subpentagonalis*, new species: 13–15, anterior, dorsal, and side views, ×1, of a young paratype, USNM 380427; 16–18, dorsal, side, and anterior views, ×1, of a young adult, paratype, USNM 380509b; 19–21, anterior, side, and dorsal views, ×1, of a young paratype, USNM 380544a; 22–24, side, anterior, and dorsal views, ×1, of a large adult, holotype, USNM 380508; 25–27, anterior, side, and dorsal views, ×1, of a paratype, USNM 380291; 28, dorsal view, ×1, of a large paratype, USNM 380489; 29, 30, exterior and interior views, of a dorsal valve, ×1, excavated to show loop, paratype, USNM 380492; 31, 32, ventral and partial side views, ×2, of the loop of the preceding dorsal valve. Localities: 13–15, S1007; 16–18, KK9-95-96; 19–21, S1478; 22–27, S1295; 28, KK9-97-98; 29–32, S1296.

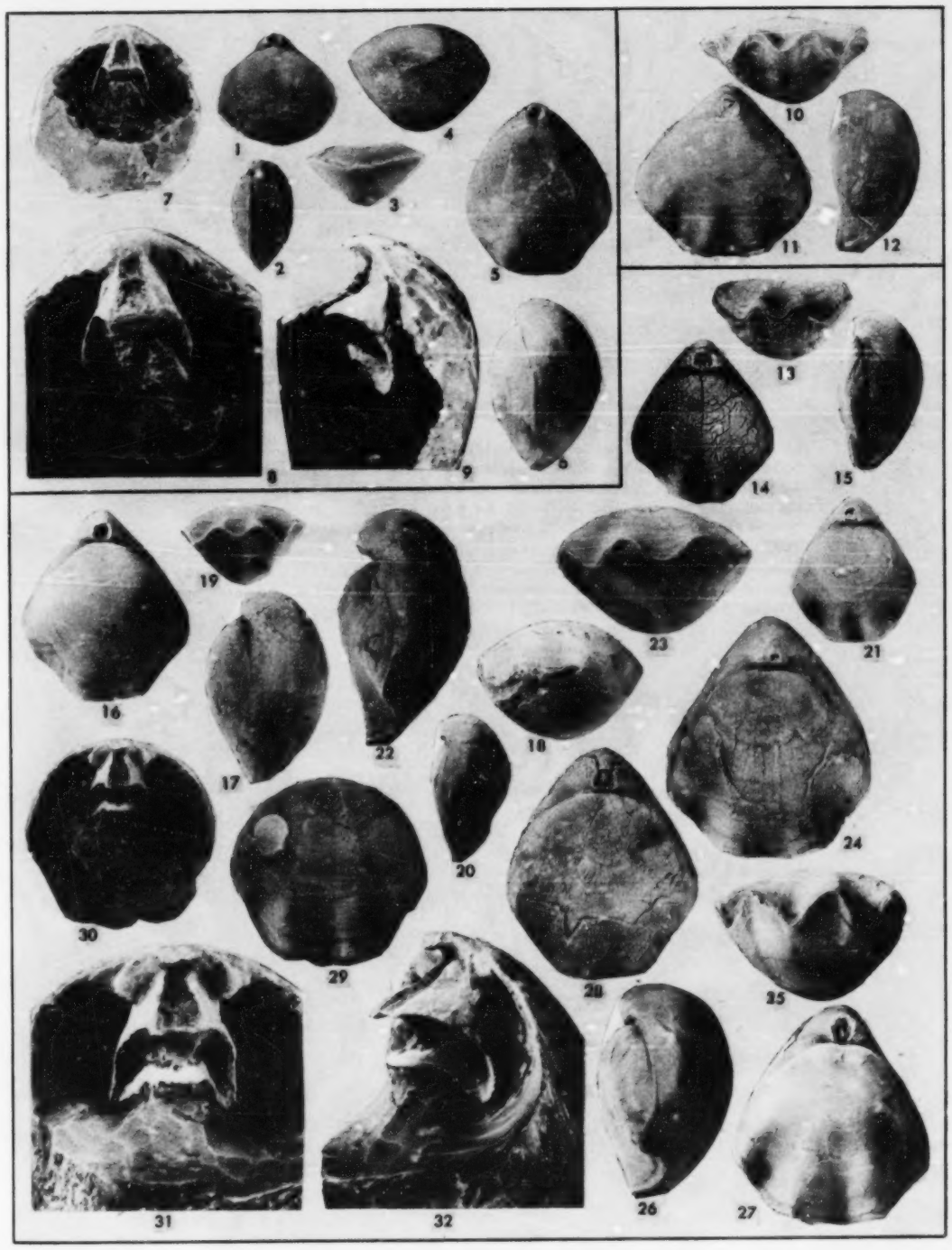
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PLATE 22

FIGURES 1–5.—*Bihenithyris simulans*, new species: 1–3, anterior, side, and dorsal views, ×1, holotype, USNM 380494a; 4, 5, ventral and partial side views of the dorsal valve showing excavated loop, ×2, paratype, USNM 380494b. Locality S1469.

FIGURES 6–20.—*Arapsothyris magna*, new species: 6–8, dorsal, side, and anterior views, ×1, of a large, strongly concave paratype, USNM 380432. 9–12, dorsal, ventral, side, and anterior views, ×1, of a young paratype, USNM 380531; 13–15, anterior, side, and dorsal views, ×1, of the holotype, USNM 380289; 16, dorsal view, ×1, of a young paratype, USNM 380542; 17, interior of the dorsal valve with excavated loop, ×1, paratype, USNM 380485; 18–20, posterior, partial side, and ventral views, ×2, of the preceding paratype. Localities: 6–8, S743; 9–12, 16–20, S1478; 13–15, S1146.

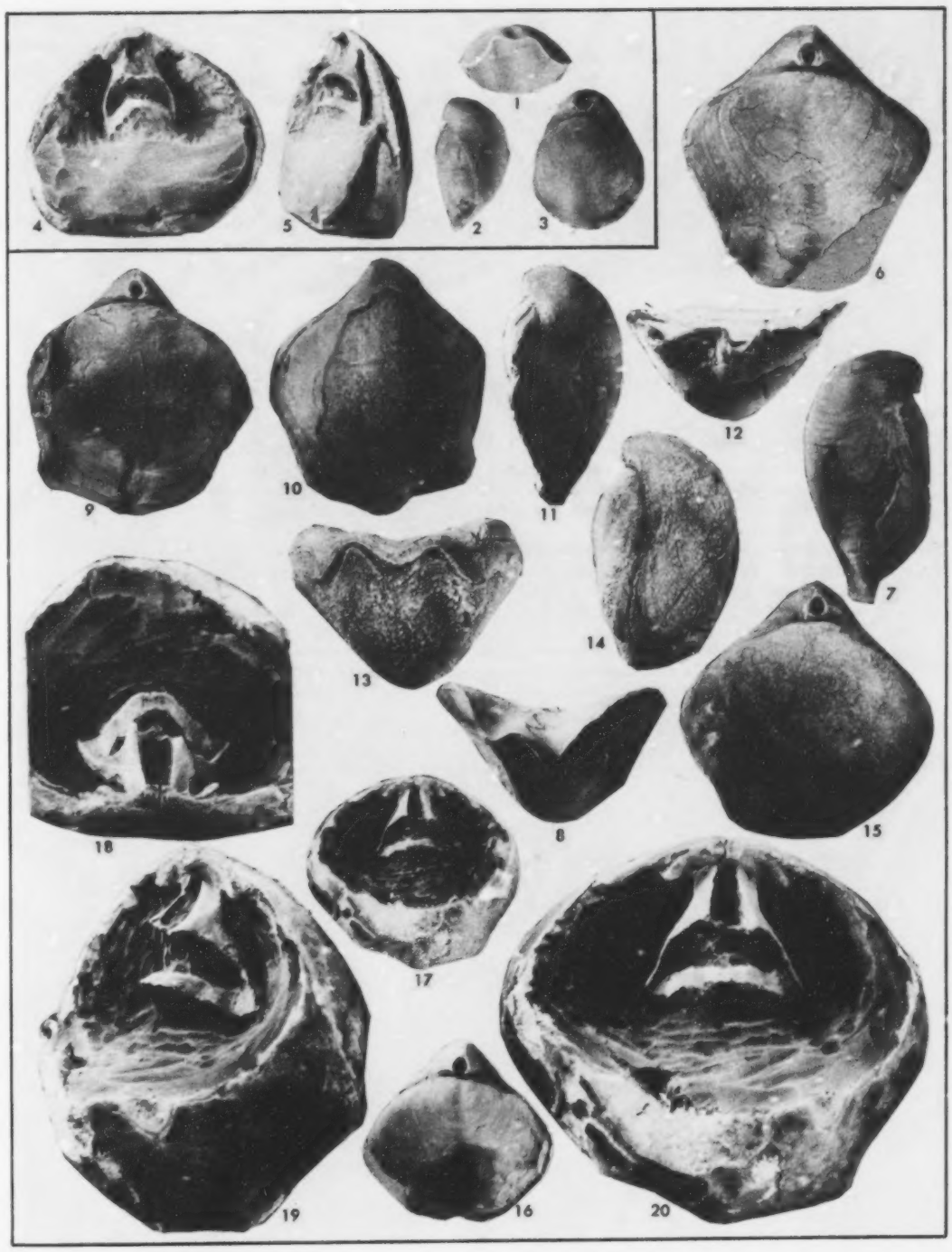
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PLATE 23

FIGURES 1–3.—*Avonothyris?* species: side, anterior, and ventral views, ×1, USNM 380304. Locality S1156.

FIGURES 4–8.—*Bihenithyris? abnormis*, new species: anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380511. Locality L916 [= S154].

FIGURES 9–11, *Bihenithyris mediocostata*, new species: anterior, dorsal, and side views, ×1, holotype, USNM 380204. Locality S154.

FIGURES 12–17, *Arapsothyris angustata*, new species: 12–14, anterior, side, and dorsal views, ×1, holotype, USNM 380454a; 15–17, dorsal, anterior, and side views, ×1, of an undistorted paratype, USNM 380434. Localities: 12–14, S1460; 15–17, unknown.

FIGURES 18–20, *Arapsopleurum rotundum*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380438. Locality S154.

FIGURES 21–24.—*Arapsopleurum arabicum*, new species: 21–23, anterior, dorsal, and side views, ×1, holotype, USNM 380444; 24, partial side view, ×2, of an excavated loop, paratype, USNM 380463. Locality S154.

FIGURES 25–27.—*Arapsopleurum dubium*, new species: anterior, dorsal, and side views, ×1, holotype, USNM 380496. Locality S154.

FIGURES 28–33.—*Arabicella subplana*, new species: 28–30, dorsal, anterior, and side views, ×1, holotype, USNM 380488b; 31, dorsal view, ×1, of a young paratype, USNM 380545; 32, 33, partial side, and ventral views, ×2, of an excavated loop, paratype, USNM 380487. Localities: 28–30, KK9-97–98, 31–33, S1730.

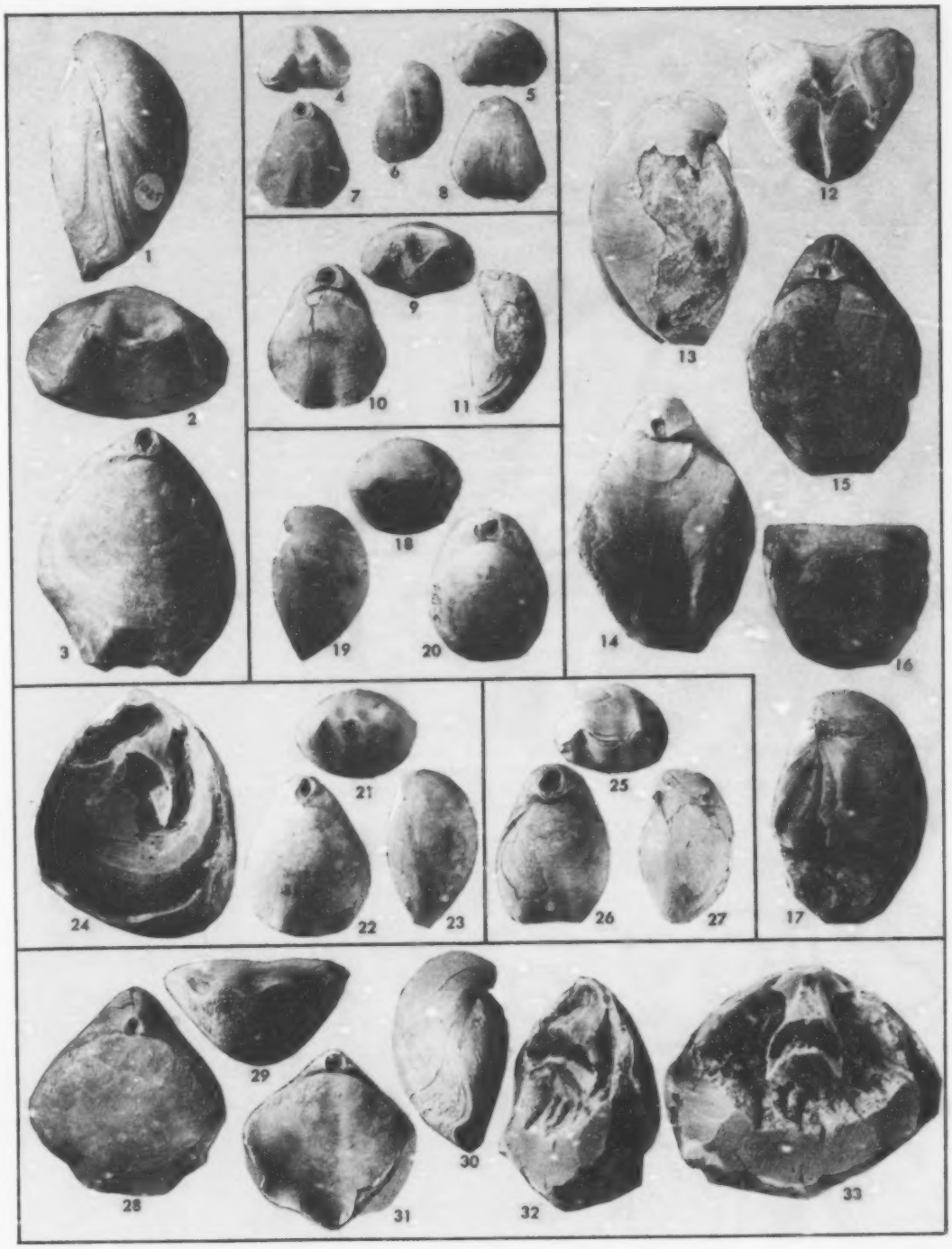
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PLATE 24

FIGURES 1–8.—*Bihenithyris deformata*, new species: 1–3, side, dorsal, and anterior views, ×1, holotype, USNM 380435a; 4, 5, dorsal and ventral views, ×1, paratype, USNM 380435c; 6, ventral view, ×1, of excavated loop, paratype, USNM 380479; 7, 8, ventral and partial side views, ×2, of the preceding paratype. Locality S1467.

FIGURES 9–13, *Bihenithyris* species: 9, 10, side and dorsal views, ×1, of a distorted specimen USNM 380478a; 11, dorsal view of cast of specimen excavated to show loop, ×1, USNM 380478b; 12, 13, partial side and ventral views, ×2, of excavated specimen showing loop, USNM 380478b. Locality S1467.

FIGURES 14–16.—*Dissoria tribulis*, new species: side, anterior, and dorsal views, ×1, holotype, USNM 380526. Locality S296.

FIGURES 17–23.—*Toxonelasma arabicum*, new species: 17–19, side, anterior, and dorsal views, ×1, paratype, USNM 380385c; 20–22, anterior, side, and dorsal views, ×1, holotype, USNM 380412a; 23, section along plane of articulation showing convex hinge plates, ×2, paratype, USNM 380412b. Locality S1618.

FIGURES 24–27.—*Bihenithyris triangulata*, new species: dorsal, anterior, ventral, and side views, ×1, holotype, USNM 380530. Locality S1790.

FIGURES 28–39.—*Bihenithyris quadrilobata*, new species: 28–30, side, anterior, and dorsal views, ×1, of a young paratype, USNM 380205c; 31–33, side, anterior, and dorsal views, ×1, holotype, USNM 380205a; 34–36, side, anterior, and dorsal views, ×2, of the holotype; 37, ventral view of an excavated loop, ×1, paratype, USNM 380433; 38, 39, ventral and partial side views, ×2, of the preceding paratype. Locality KK9-112.

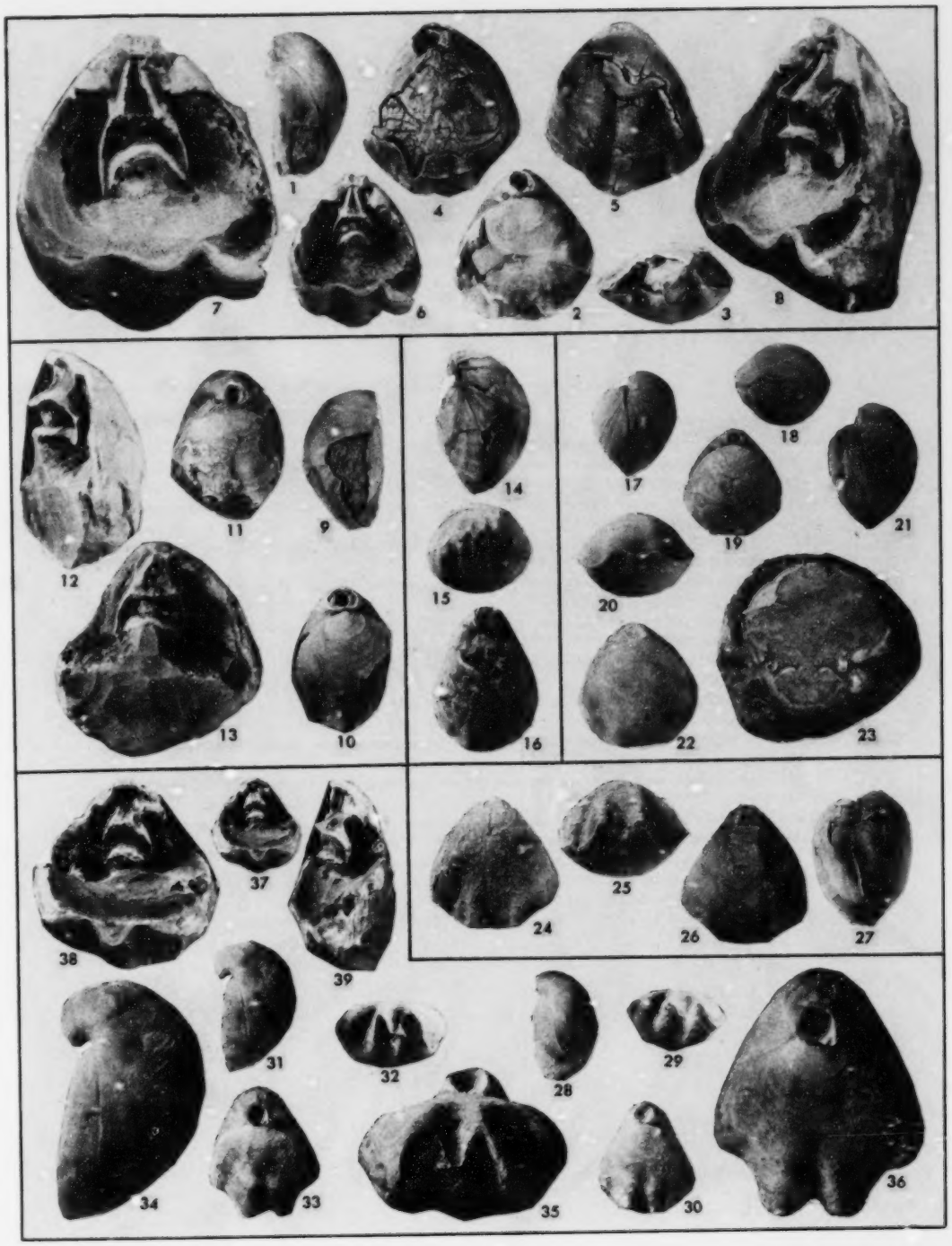
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PLATE 25

FIGURES 1–4.—*Dissoria costata*, new species: 1–3, dorsal, anterior, and side views, ×1, holotype, USNM 380436; 4, interior of a silicified specimen, ×1, showing hinge plates and descending lamellae, paratype, USNM 380464. Locality S1702.

FIGURES 5–7.—*Plectothyris?* species: side, anterior, and dorsal views, ×1, of a peripherally costate specimen, USNM 380373. Locality S1485.

FIGURES 8–11.—*Orthotoma?* species: 8, dorsal view, ×1, USNM 380265; 9–11, anterior, side, and dorsal views of the same specimen, ×2. Locality KK7-39.

FIGURES 12–15.—*Pleuraloma anomalum*, new species: ventral, anterior, side, and dorsal views, ×1, holotype, USNM 380353. Locality S296.

FIGURES 16–18.—*Pleuraloma? circulare*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380468. Locality S293.

FIGURES 19–21.—*Pleuraloma multicostatum*, new species: dorsal, anterior, and side views, ×1, holotype, USNM 380407. Locality S1702.

FIGURES 22–24.—*Pleuraloma subaequicostatum*, new species: Side, anterior, and dorsal views, ×1, holotype, USNM 380409. Locality S1702.

FIGURES 25–27.—*Pseudowattonithyris?* species. Side, dorsal, and anterior views, ×1, USNM 380414. Locality KK9-102.

FIGURES 28–30. *Dissoria obscura*, new species: Side, anterior, and dorsal views, ×1, holotype, USNM 380285a. Locality S1702.

FIGURES 31–37.—*Gyrosina? ovata*, new species: 31–33, dorsal, anterior, and side views, ×1, holotype, USNM 380473a; 34, interior of excavated dorsal valve showing loop, ×1, paratype, USNM 380473b; 35–37, ventral, partial side, and posterior views, ×2, of the preceding specimen. Locality S154.

FIGURES 38–42.—*Dorsoplicathyris?* species: 38–40, side, anterior, and dorsal views, ×1, USNM 380417; 41, dorsal view, ×1, of a silicified hypotype, USNM 380418; 42, posterior of the preceding specimen, ×2, showing hinge plates. Localities: 38–40, S625; 41, 42, S1050.

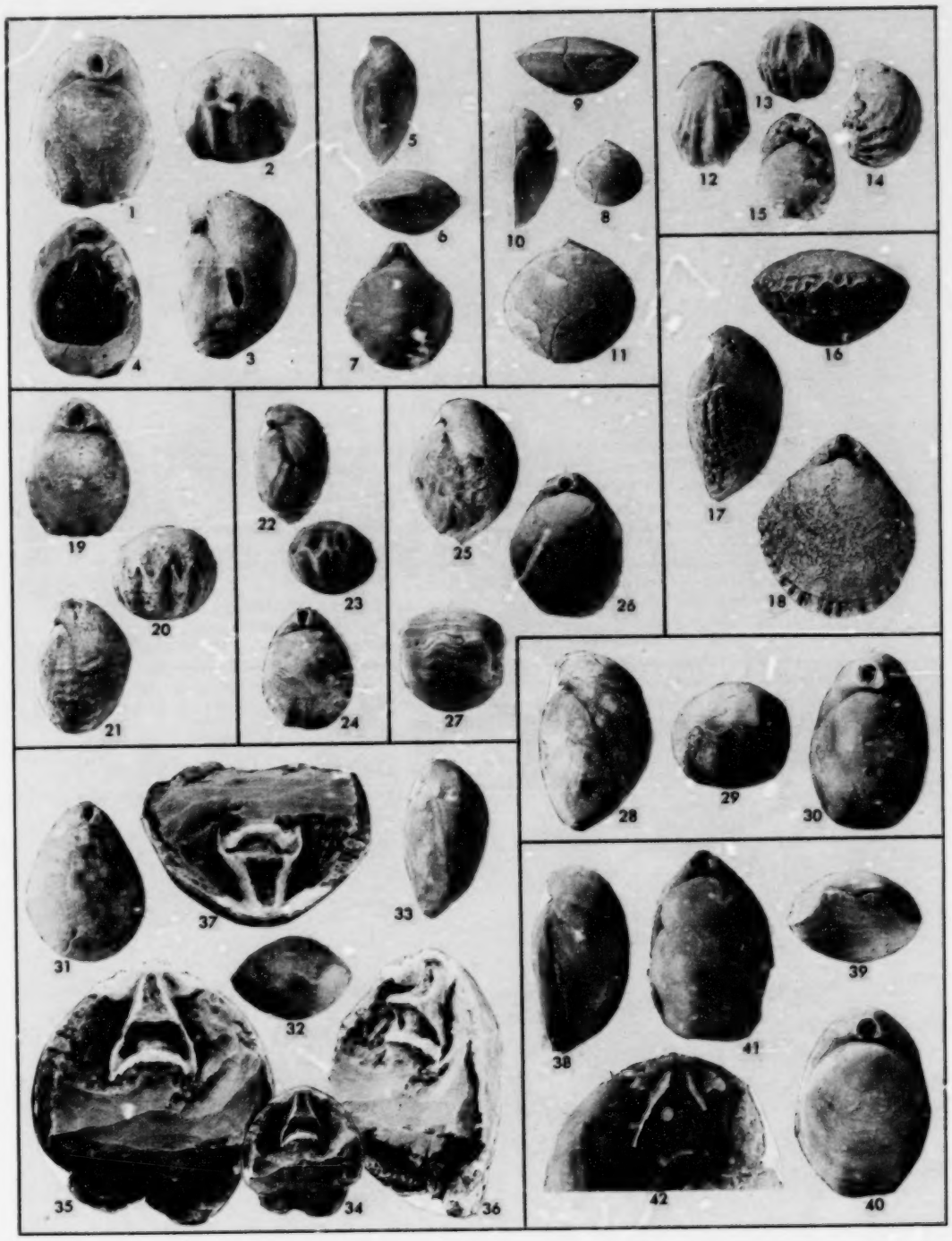
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PLATE 26

FIGURES 1–3.—*Glyphisaria?* species: 1–3, anterior, side, and dorsal views, ×1, USNM 380428a. Locality S1702.

FIGURES 4–9.—*Glyphisaria? divergens*, new species: 4–6, dorsal, side, and anterior views, ×1, holotype, USNM 380282a; 7, dorsal view, ×1, of a silicified paratype, USNM 380296; 8, 9, ventral views, ×2, of the preceding silicified specimen showing loop. Locality KK10-25.

FIGURES 10–18.—*Pionopleurum compactum*, new species: 10–12, anterior, side, and dorsal views, ×1, holotype, USNM 380408; 13–15, dorsal, anterior, and side views, ×1, of a young paratype, USNM 380484a; 16, ventral view, ×1, of dorsal valve with excavated loop, paratype, USNM 380484e; 17, 18, ventral and partial side views, ×2, of the preceding specimen. Locality S1447.

FIGURES 19–21.—*Loboidothyris?* species: dorsal, anterior, and side views, ×1, USNM 380472. Locality S1167.

FIGURES 22–27.—*Dolichobrochus? ovatus*, new species: 22–24, anterior, side, and dorsal views, ×1, holotype, USNM 380495a; 25, ventral view, ×1, of a dorsal valve with excavated loop, paratype, USNM 380495b; 26, 27, ventral and partial side views, ×2 of the preceding dorsal valve. Locality S154.

FIGURES 28–30.—*Kutchithyris?* species 2: anterior, side, and dorsal views, ×1, USNM 380415. Locality S293.

FIGURES 31–34.—*Gyrosina?* species: partial side, opposite side, posterior, and ventral views of a dorsal valve, ×2, excavated to show loop, USNM 380475. Locality S1469.

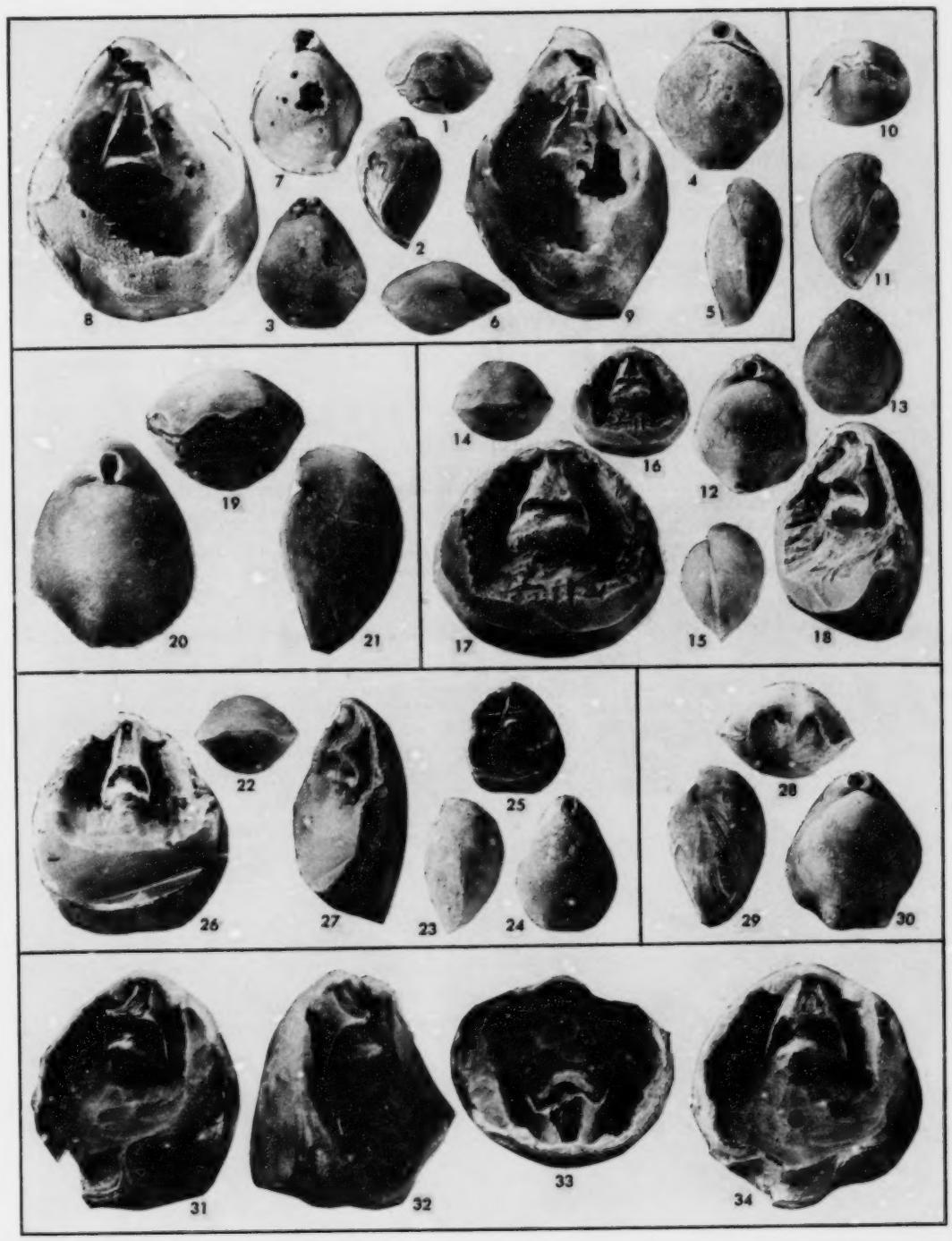
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PLATE 27

FIGURES 1–6.—*Pleuraloma* species: 1–3, dorsal, anterior, and side views, ×1, USNM 380525a; 4–6, ventral and two side views, ×2, of a dorsal valve excavated to show the loop, USNM 380525b. Locality S1715.

FIGURES 7–9.—*Kutchithyris?* species 1: anterior, side, and dorsal views, ×1, USNM 380437a. Locality S1476.

FIGURES 10–12.—*Pleuraloma robustum*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380470. Locality S1715.

FIGURES 13–15.—*Pleuraloma triangulatum*, new species: anterior, side, and dorsal views, ×1, showing flattened margin, holotype, USNM 380403. Locality S1702.

FIGURES 16–18.—*Pleuraloma convexum*, new species: side, anterior, and dorsal views, ×1, holotype, USNM 380406. Locality S154.

FIGURES 19–21.—*Pleuraloma abruptum*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380269. Locality S154.

FIGURES 22–36.—*Pionopleurum obesum*, new species: 22–24, anterior, side, and dorsal views, ×1, paratype, USNM 380482; 25, dorsal view, ×1, of a slightly crushed specimen, paratype, USNM 380481b; 26–28, side, anterior, and dorsal views, ×1, of the holotype, USNM 380290; 29–31, anterior, side, and dorsal views, ×1, of a paratype, USNM 380483b; 32, 33, dorsal and side views, ×1, of another paratype, USNM 380483a; 34, ventral view, ×1, of a dorsal valve excavated to show the loop, paratype, USNM 380481c; 35, 36, ventral and partial side views, ×2, of the preceding dorsal valve. Localities: 22–24, S1457; 25–28, 34–36, S1446; 29–33, S1449.

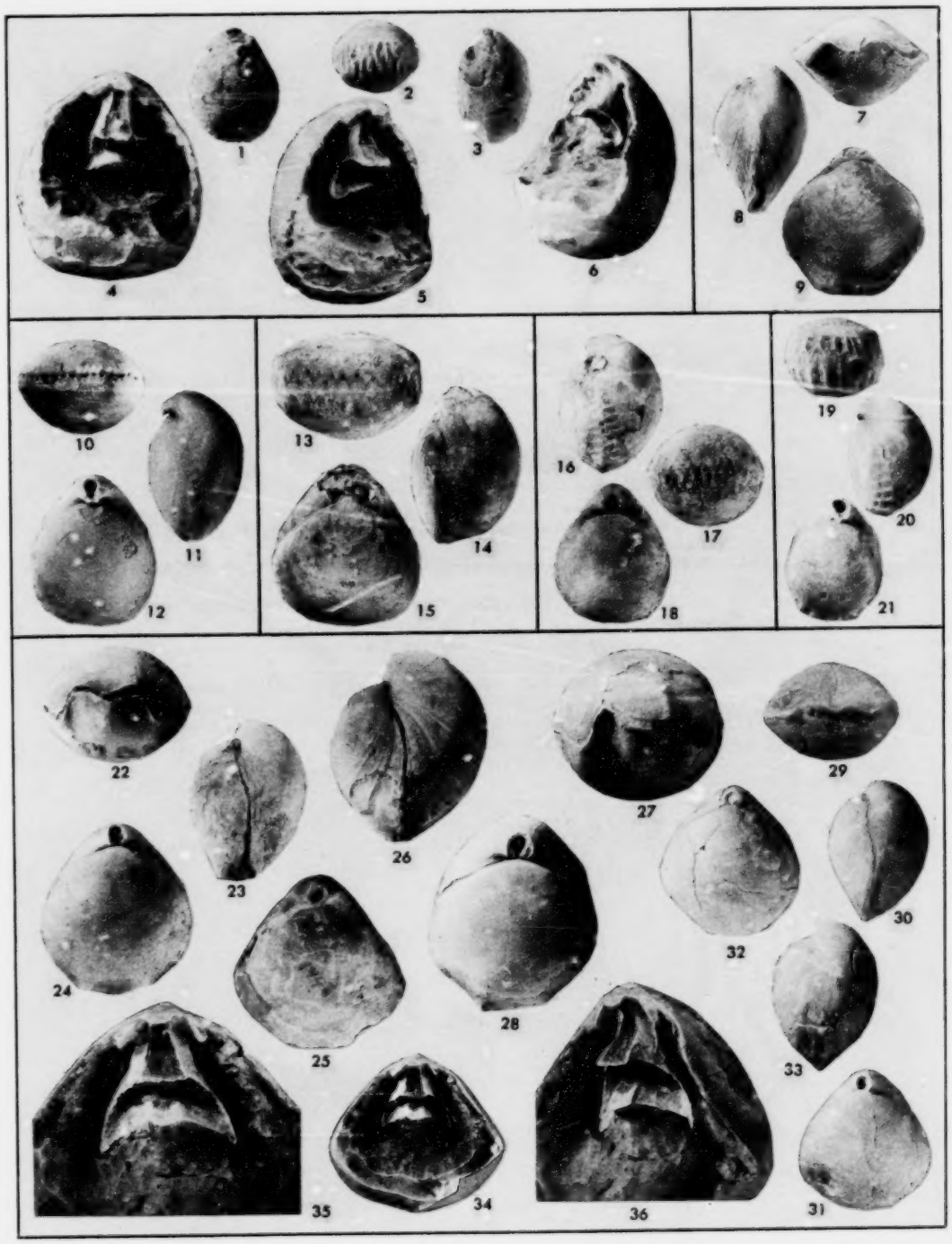
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PLATE 28

FIGURES 1–9.—*Pleuraloma labiatum*, new species: 1–3, anterior, dorsal, and side views, ×1, holotype, USNM 380465a; 4, ventral view, ×1, of the dorsal valve excavated to show the loop, paratype, USNM 380465b; 5, 6, ventral and partial side views, ×2, of preceding dorsal valve; 7–9, side, anterior, and dorsal views, ×1, paratype, USNM 380402. Localities: 1–6, S296; 7–9, S1702.

FIGURES 10–12.—*Glyphisaria? divergens*, new species: dorsal, side, and anterior views, ×1, paratype, USNM 380638. Locality KK10-25.

FIGURES 13–16.—*Pleuraloma varicostatum*, new species: ventral, side, anterior, and dorsal views, ×1, holotype, USNM 380356. Locality S1702.

FIGURES 17–19. Terebratulacean genus and species undetermined 1: side, anterior, and dorsal views, ×1, USNM 380237. Locality KK10-25.5.

FIGURES 20–22.—*Somalithyris elliptica*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380538. Locality KK10-25.5.

FIGURES 23–42.—*Somalithyris ovata*, new species: 23–25, dorsal, anterior, and side views, ×1, holotype, USNM 380203a; 26–28, dorsal, anterior, and side views, ×1, paratype, USNM 380293a; 29–31, anterior, side, and dorsal views, ×1, paratype, USNM 380293b; 32, dorsal view, ×1, of a paratype showing elongate muscle scars through translucent shell, USNM 380416; 33–35, anterior, side, and dorsal views, ×1, of a narrow paratype, USNM 380541; 36, interior of a dorsal valve of a silicified specimen showing elongate adductor scars, ×1, paratype, USNM 380533; 37–39, dorsal, side, and anterior views, ×1, paratype, USNM 380236; 40, dorsal view, ×1, of a silicified specimen, USNM 280295; 41, interior, ×2, of the preceding specimen showing pedicle collar and loop. 42, silicified specimen, ×2, showing loop, paratype, USNM 380535. Localities: 23–25, KK10-25; 26–31, 37–41, KK10-25.5; 32, KK10-26; 33–36, KK10-35; 42, KK10-37.5.

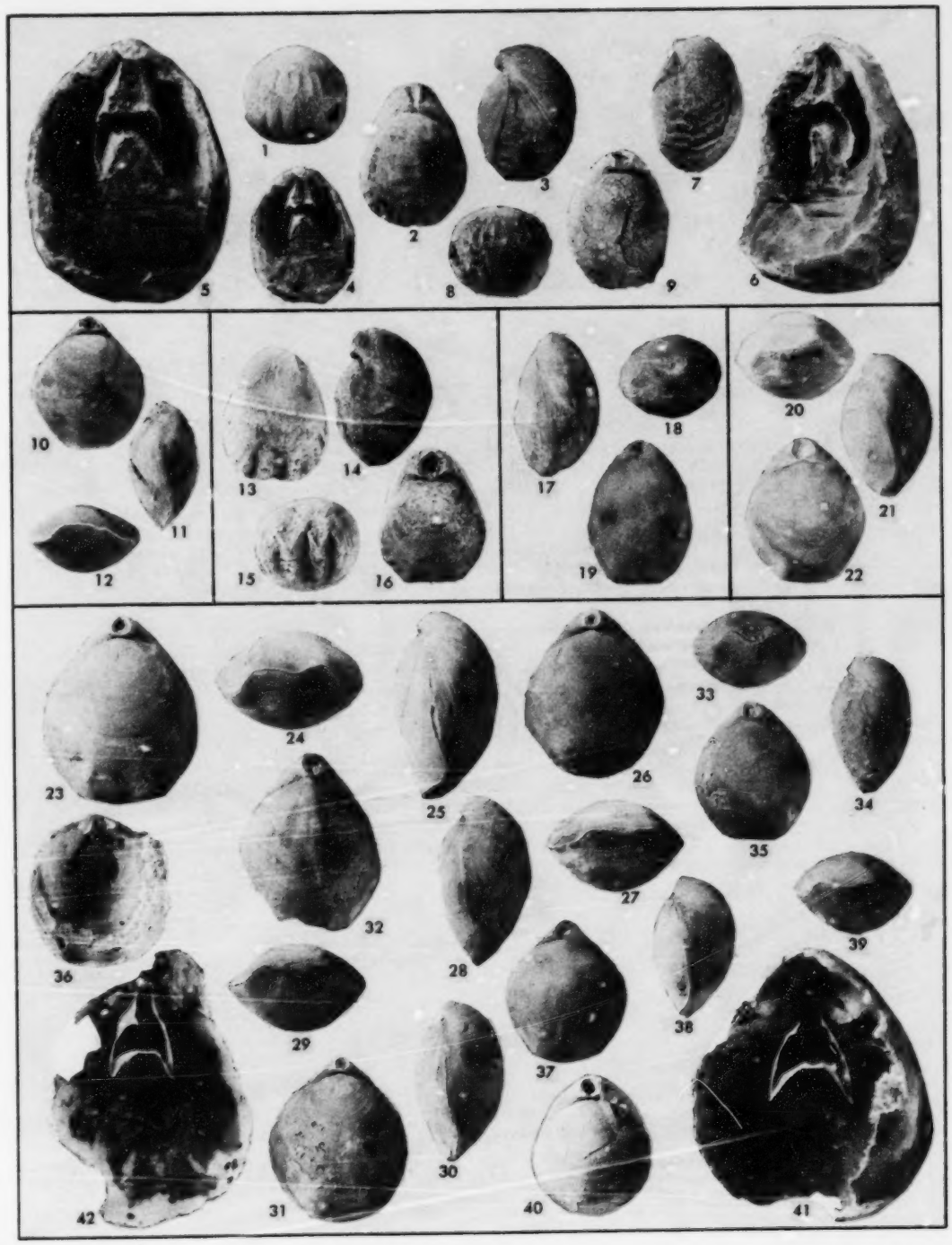
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PLATE 29

FIGURES 1–4.—*Somalithyris parva*, new species: 1–3, anterior, side, and dorsal views, ×1, holotype, USNM 380527a; 4, side view, ×2, of a dorsal valve showing loop, paratype, USNM 380524. Localities: 1–3, KK10-25.5; 4, KK10-25.

FIGURES 5–7.—*Somalithyris rotundata*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380284. Locality S776.

FIGURES 8–14.—*Somalithyris subcircularis*, new species: 8–10, side, anterior, and dorsal views, ×1, paratype, USNM 380528; 11–13, anterior, dorsal, and side views, ×1, holotype, USNM 380222; 14, posterior of a silicified dorsal valve, ×2, showing loop, paratype, USNM 380529. Localities: 8–13, KK10-25; 14, KK10-25.5.

FIGURES 15–19, *Somalithyris triangulata*, new species: 15, dorsal view of a silicified paratype, ×1, USNM 380419; 16, posterior of the dorsal valve of the preceding paratype, ×2, showing cardinalia; 17–19, anterior, dorsal, and side views, ×1, holotype, USNM 380420. Localities: 15, 16, KK10-25.5; 17–19, S1443.

FIGURES 20–22.—*Sphaeroidothyris* species 1: anterior, side, and dorsal views, ×1, USNM 380386. Locality S1166.

FIGURES 23–25.—*Sienorina parallela*, new species: anterior, side, and dorsal views, ×1, holotype, USNM 380283. Locality KK9-112–114.

FIGURES 26–34.—*Sphaeroidothyris arabica*, new species: 26–28, dorsal, anterior, and side views, ×1, holotype, USNM 380486a; 29, dorsal valve excavated to show loop, ×1, paratype, USNM 380486b; 30, 31, partial side and ventral views, ×2, of the preceding dorsal valve; 32–34, dorsal, anterior, and side views, ×1, of a paratype, USNM 380411. Localities: 26–31, S1001; 32–34, S1166.

FIGURES 35–39.—*Sphaeroidothyris sphaeroidalis* (Auct.): posterior, anterior, side, ventral, and dorsal views, ×1, of a specimen with folded anterior, USNM 380209. Locality KK8.

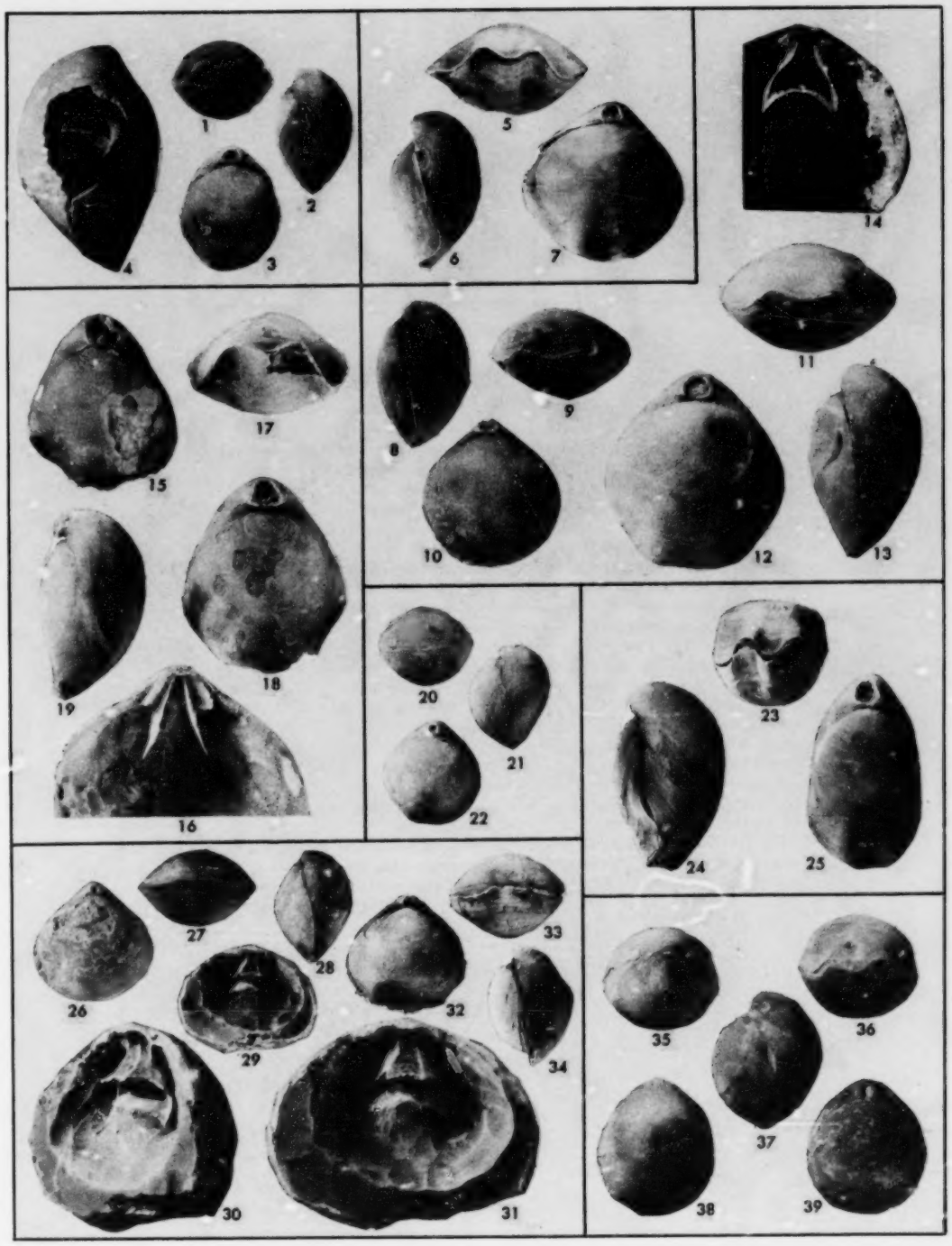
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PLATE 30

FIGURES 1–4.—*Striithyris costata*, new species: 1–3, anterior, dorsal, and side views, ×1, of a distorted specimen, holotype, USNM 380423; 4, side view, ×2, of the holotype. Locality S1309.

FIGURES 5–7.—*Sphaeroidothyris* species 2: side, anterior, and dorsal views, ×1, USNM 380497. Locality S1618.

FIGURES 8–12.—*Striithyris saudiarabica*, new species: 8–11, ventral, anterior, dorsal, and side views, ×1, holotype, USNM 380230; 12, dorsal view of the holotype, ×2. Locality S296.

FIGURES 13–17.—*Striithyris striata*, new species: 13–16, anterior, dorsal, side, and ventral views, ×1, holotype, USNM 380235; 17, the holotype, dorsal view, ×2. Locality S1458.

FIGURES 18–23.—*Striithyris striata*, new species: 18–20, side, dorsal, and anterior, views, ×2, paratype, USNM 551009; 21, dorsal valve, ×1, with excavated loop, paratype, USNM 551008a; 22, 23, partial side, and ventral views of the excavated dorsal valve, ×3. Localities: 18–20, S154; 21–23, S1458.

FIGURE 24.—*Somalithyris ovata*, new species: interior of the dorsal valve, ×1, ×2, showing loop, paratype, USNM 380523. Locality KK10-25.

FIGURES 25–30.—*Tanyothyris angustata*, new species: 25–27, side, anterior, and dorsal views, ×1, holotype, USNM 380476a; 28, dorsal valve, ×1, excavated to show loop, paratype, USNM 380476e; 29, 30, partial side and ventral views, ×2, of the excavated paratype. Locality S154.

FIGURES 31–36.—*Tanyothyris symmetrica*, new species: 31–33, dorsal, anterior, and side views, ×1, holotype, USNM 380477a; 34, excavated dorsal valve, ×1, showing loop, paratype, USNM 380477b; 35, 36, ventral and partial side views, ×2, of the preceding dorsal valve of paratype. Locality S154.

FIGURES 37–40.—Terebratulacean genus and species undetermined 2: side, ventral, dorsal, and anterior views, ×1, showing indistinct costation, USNM 380421. Locality S1167.

FIGURES 41–43.—*Pseudoglossothyris? sulcata* Muir-Wood [= *Aulacothyris sulcata*]: 41, 42, side and dorsal views, ×1, of a hypotype, USNM 380466a; 43, fragmentary dorsal valve, ×1, showing cardinalia and thick median septum, hypotype, USNM 380466b. Jurassic, 6 miles north of Dire Daua, Abyssinia.

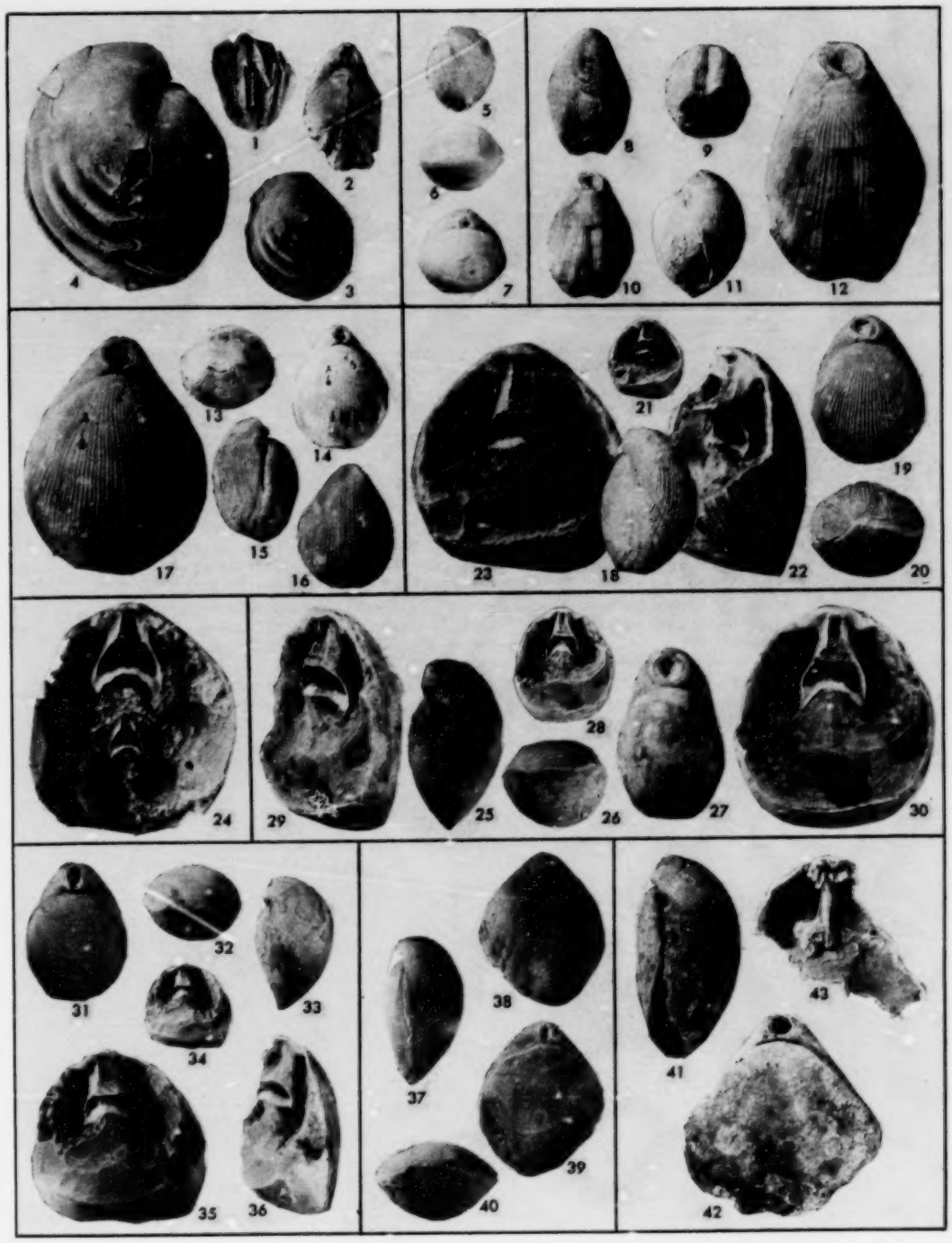
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PLATE 31

FIGURES 1–3.—*Calyptoria carinata*, new species: anterior, dorsal, and side views, ×2, showing carinate fold, paratype, USNM 380324c. Locality S1031.

FIGURES 4–6.—*Pleuraloma convexum*, new species: anterior, side, and dorsal views, ×1, paratype, USNM 380476. Locality S154.

FIGURES 7–12, *Stiphrothyris?* species 2: 7–9, side, anterior, and dorsal views, ×1, USNM 380387a; 10–12, dorsal, anterior, and side views, ×1, USNM 380387b. Locality S1695.

FIGURES 13–21.—*Habrobrochus amygdaloideus*, new species: 13–15, dorsal, side, and anterior views, ×1, holotype, USNM 380474a; 16, dorsal valve, ×1, excavated to show loop, paratype, USNM 380474d; 17, 18, ventral and partial side views, ×2, of the preceding dorsal valve of paratype, USNM 380474d; 19, ventral view, ×1, dorsal valve excavated to show the loop, paratype, USNM 380512b; 20, 21, partial side, and ventral views, ×2, of the preceding dorsal valve of paratype, USNM 380512b. Localities: 13–18, S1443; 19–21, S1467.

FIGURES 22–27.—*Stiphrothyris?* species 1: 22–24, side, dorsal, and anterior views, ×1, USNM 380471a, 25, Plaster cast, ×1, of a specimen excavated to show the loop, USNM 380471b; 26, 27, excavated dorsal valve, ×2, USNM 380471b. Locality S1167.

FIGURES 28–31. Terebratulacean genus and species undetermined 3: 28–30, anterior, side, and ventral views, ×1, USNM 380510; 31, silica-filled specimen, ×2, showing shadow of loop, ×2, USNM 380540. Localities: 28–30, S1167; 31, S1164.

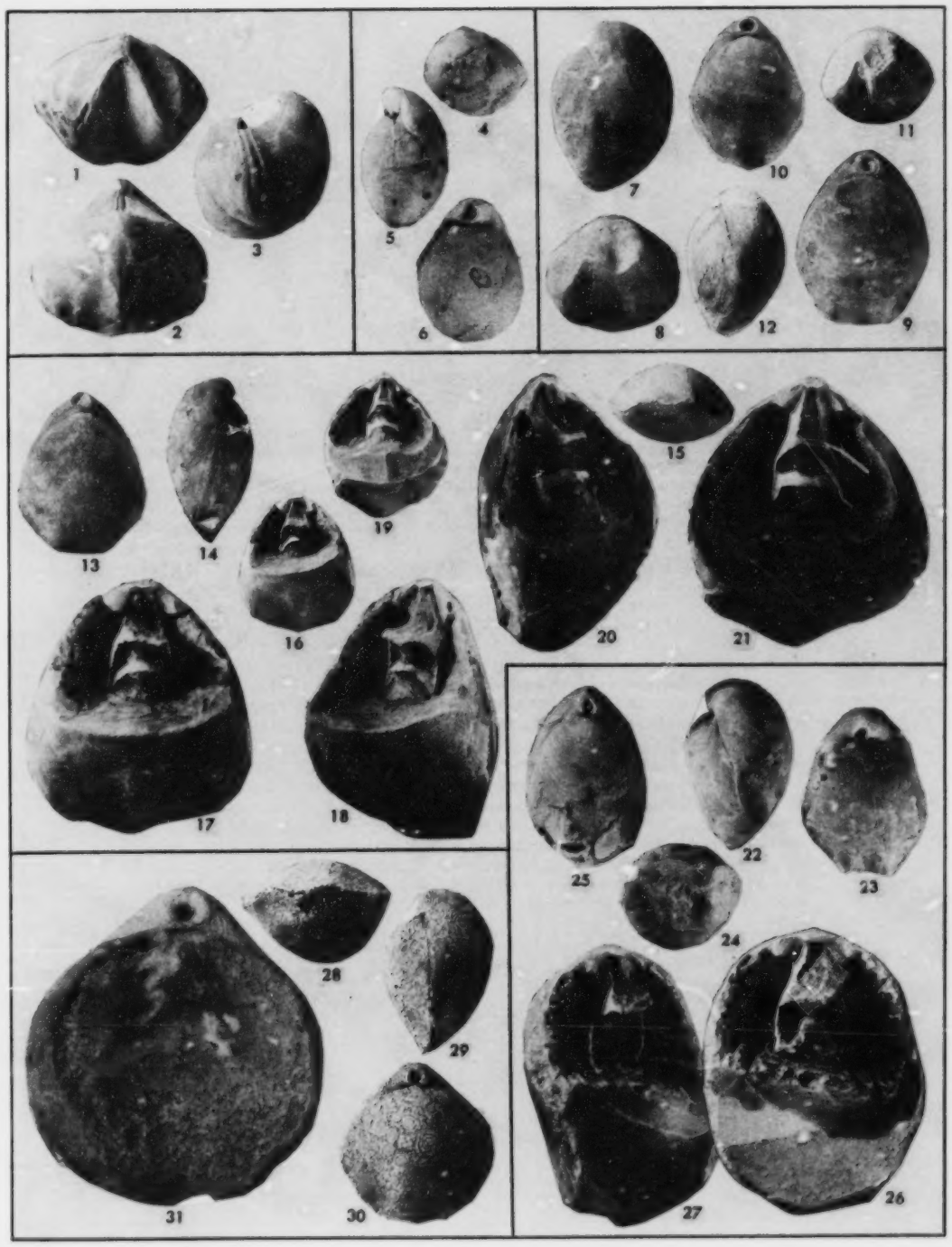
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PLATE 32

FIGURES 1–5.—*Zeilleria* species 1: 1, dorsal view, ×1, USNM 380358; 2–5, anterior, dorsal, side, and ventral views of the preceding specimen, ×2. Locality S154.

FIGURES 6–17.—*Mycerosia amygdaliformis*, new species: 6–8, dorsal, side, and anterior views, ×2, paratype, USNM 380244b; 9–11, anterior, side, and dorsal views, ×2, paratype, USNM 380244c; 12, dorsal view, ×1, holotype, USNM 380245c; 13–15, anterior, dorsal, and side views, ×3, of the holotype; 16, ventral valve interior showing teeth, ×2, paratype, USNM 380302a; 17, interior of dorsal valve, ×2, showing spiny loop, counterpart of preceding ventral valve, paratype, USNM 380302b. Localities: 6–11, KK10-25.5; 12–15, KK10-26; 16, 17, KK10-25.

FIGURES 18–25.—*Flabellothyris flabella* (Defrance): 18–22, anterior, dorsal, posterior, side, and ventral views, ×1, hypotype, USNM 380306; 23–25, anterior, side, and dorsal views, ×2, of the same hypotype. Locality S1001.

FIGURES 26–35.—*Rugitela primaria*, new species: 26–28, anterior, dorsal, and side views, ×1, paratype, USNM 380211b; 29–31, anterior, side, and dorsal views, ×1, holotype, USNM 380211a; 32–34, anterior, side, and dorsal views, ×2, of the holotype; 35, posterior view of a decorticated specimen, ×2, showing dental plates and median myophragm between the dental plates, paratype, USNM 380515a. Localities: 26–34, S1034; 35, S989.

FIGURES 36–63.—*Apothyris aberrans*, new species: 36, dorsal view, ×1, paratype USNM 380321a; 37–41, dorsal, ventral, side, posterior, and anterior views, ×2, of the preceding paratype; 42, dorsal view, ×1, of a narrow paratype, USNM 380321b; 43–47, side, anterior, posterior, dorsal, and ventral views, ×2, of the preceding paratype, USNM 380321b; 48, dorsal view, ×1, of a narrow paratype, USNM 380352; 49–53, anterior, posterior, ventral, side, and dorsal views, ×2, of the preceding paratype, USNM 380352; 54, dorsal view, ×1, holotype, USNM 380392a; 55–59, ventral, anterior, posterior, side, and dorsal views, ×2, of the holotype; 60–63, anterior, posterior, side, and dorsal views, ×1, of a paratype USNM 380311. Localities: 36–47, S1462; 48–53, 60–63, KK9-122; 54–59, S1471.

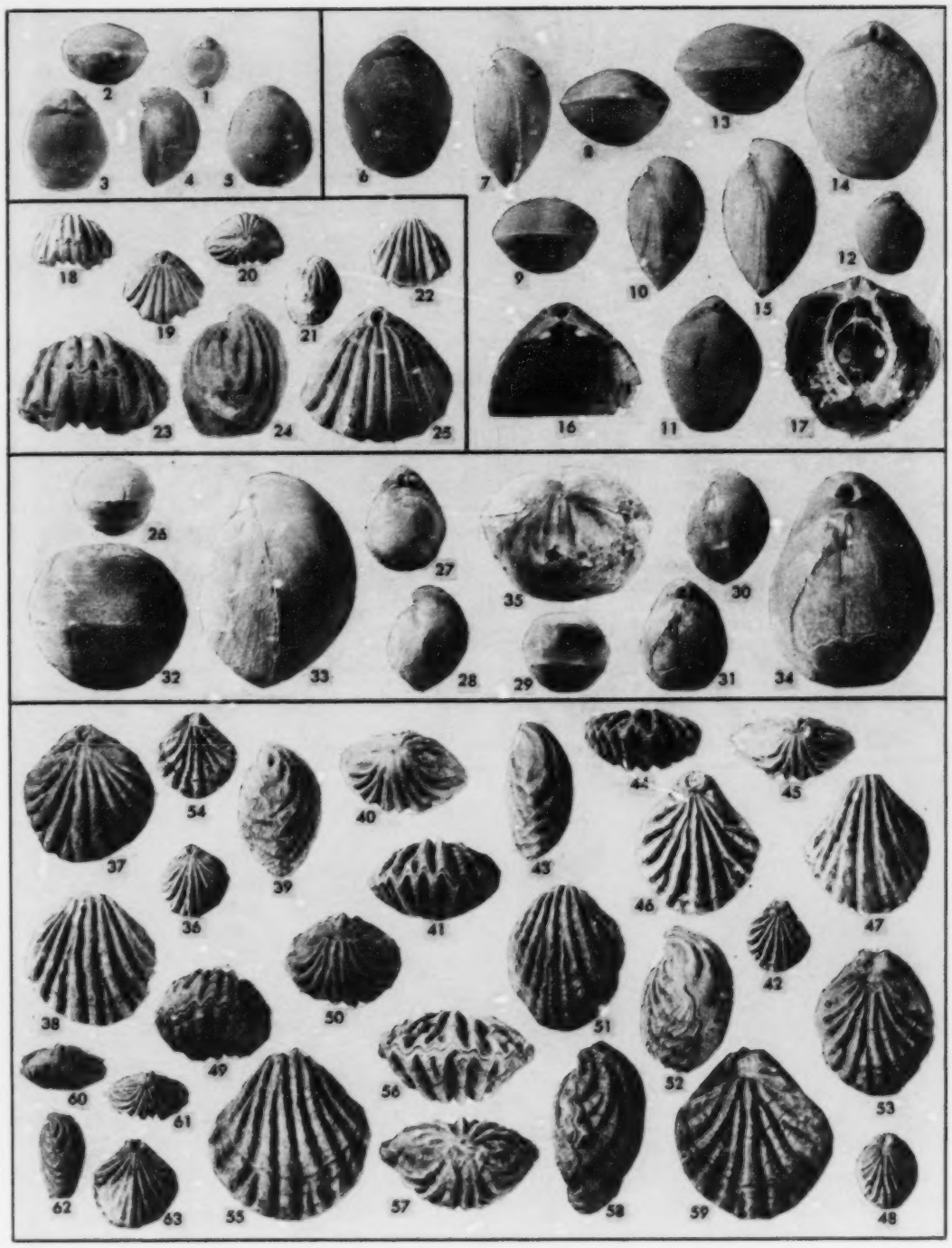
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PLATE 33

FIGURES 1–9.—*Sphriganaria angulocostata*, new species: 1–5, ventral, posterior, side, dorsal, and anterior views, ×1, paratype, USNM 380335b; 6–9, dorsal, side, ventral, and anterior views, ×1, of the holotype USNM 380536a. Localities: 1–5, KK9-90; 6–9, S1743.

FIGURES 10–17.—*Sphriganaria angustata*, new species: 10–14, ventral, anterior, dorsal, side, and posterior views, ×1, holotype, USNM 380319a; 15–17, anterior, side, and dorsal views, ×2, of the holotype. Locality S1440.

FIGURES 18–22.—*Sphriganaria arguta*, new species: ventral, anterior, side, posterior, and dorsal views, ×1, holotype, USNM 380504. Locality S1449.

FIGURES 23–32.—*Sphriganaria bicostata*, new species: 23–27, dorsal, anterior, ventral, posterior, and side views, ×1, holotype, USNM 380362a; 28–32, anterior, posterior, side, dorsal, and ventral views, ×1, paratype, USNM 380363. Localities: 23–27, S1457; 28–32, S1618.

FIGURES 33–37.—*Sphriganaria curtirostra*, new species: anterior, posterior, side, dorsal, and ventral views, ×1, holotype, USNM 380500. Locality S743.

FIGURES 38–55.—*Sphriganaria bramkampi*, new species: 38–41, ventral, side, dorsal, and posterior views, X1, paratype, USNM 380310b; 42–45, ventral, side, anterior, and dorsal views, ×1, holotype, USNM 380310a; 46–50, anterior, dorsal, ventral, side, and posterior views, ×1, paratype, USNM 380316; 51–55, posterior, anterior, ventral, side, and dorsal views, ×1, paratype, USNM 380331a. Localities: 38–45, KK9-112; 46–50, S154; 51–55, S1311.

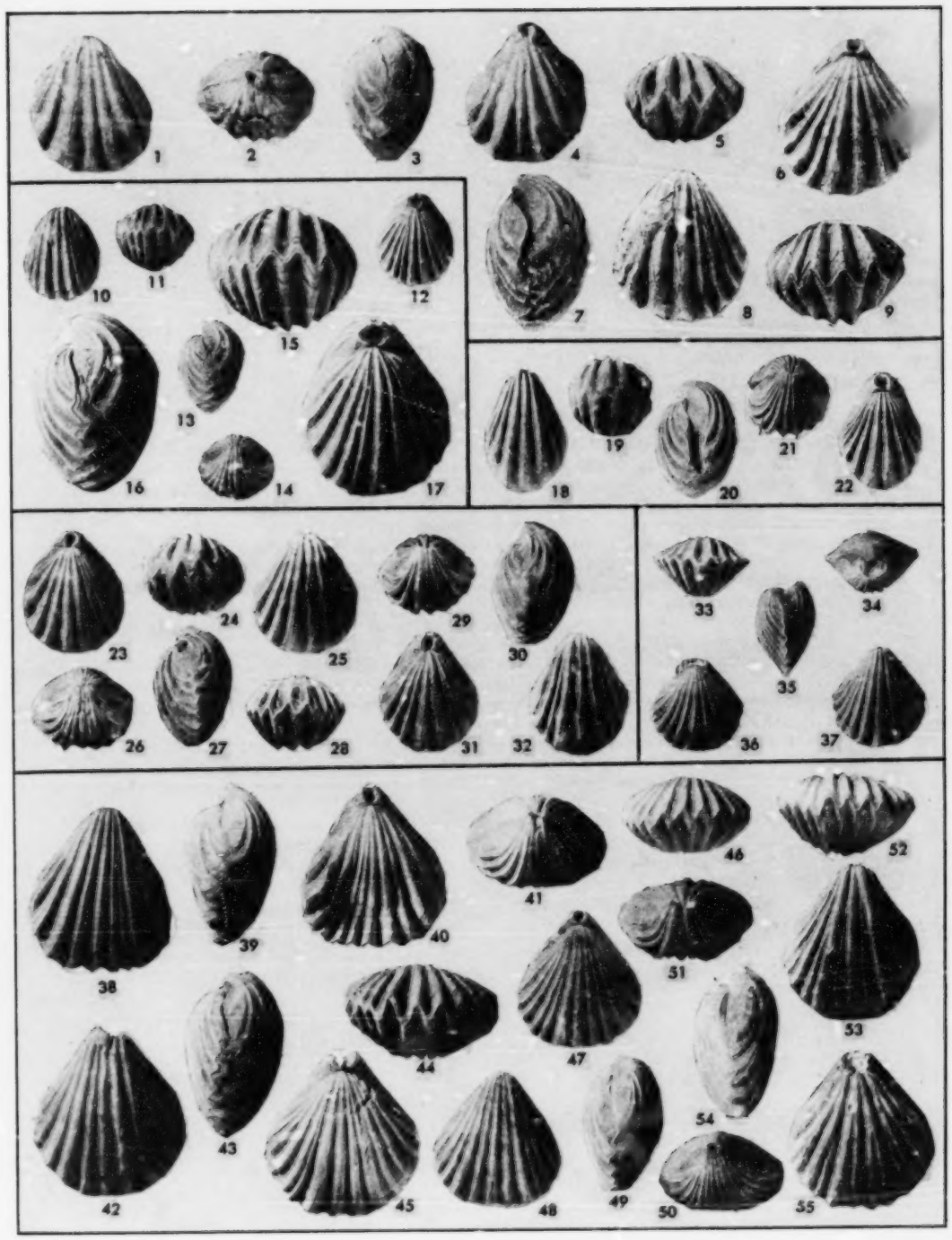
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PLATE 34

FIGURES 1–10.—*Sphriganaria costellata*, new species: 1–5, ventral, posterior, anterior, side, and dorsal views, ×1, paratype, USNM 380312; 6–10, ventral anterior, dorsal, posterior, and side views, ×1, holotype, USNM 400931a. Localities: 1–5, S1046; 6–10, KK8-30-35.

FIGURES 11–16.—*Sphriganaria lirata*, new species, holotype, USNM 380442: 11–15, posterior, anterior, ventral, side, and dorsal views, ×1; 16, dorsal view, ×1.5. Locality S1160.

FIGURES 17–27.—*Sphriganaria distincta*, new species: 17–21, posterior, side, anterior, ventral, and dorsal views, ×1, paratype, USNM 380320a; 22, dorsal view, ×2, of the preceding paratype, USNM 380320a; 23–27, ventral, posterior, side, anterior, and dorsal views, ×1, of the holotype, USNM 380340. Localities: 17–22, S1440; 23–27, KK8-23.

FIGURES 28–32.—*Sphriganaria elliptica*, new species: anterior, ventral, side, dorsal, and posterior views, ×1, holotype, USNM 380343. Locality S1001.

FIGURES 33–44.—*Sphriganaria costata*, new species: 33–37, posterior, anterior, side, dorsal, and ventral views, ×1, paratype, USNM 380349a; 38, dorsal view, ×2, of the preceding paratype; 39–43, anterior, side, posterior, ventral, and dorsal views, ×1, holotype, USNM 380349b; 44, dorsal view, ×2, of the holotype. Locality S1747.

FIGURES 45–59.—*Sphriganaria expansa*, new species: 45–49, dorsal, side, posterior, anterior, and ventral views, ×1, holotype, USNM 380317b; 50–54, anterior, dorsal, side, posterior, and ventral views, ×1, paratype USNM 380317a; 55–59, anterior, dorsal, posterior, ventral, and side views, ×1, paratype, USNM 380355. Localities: 45–54, S1478; 55–59, S1742.

FIGURES 60–65.—*Sphriganria intercalata*, new species: 60–64, side, dorsal, anterior, ventral, and posterior views, ×1, holotype, USNM 380336, 65, dorsal view, ×1.5, of the holotype. Locality S1453.

FIGURES 66–70.—*Sphriganaria irregularis*, new species: posterior, anterior, side, dorsal, and ventral views, ×1, holotype, USNM 380313a. Locality S1167.

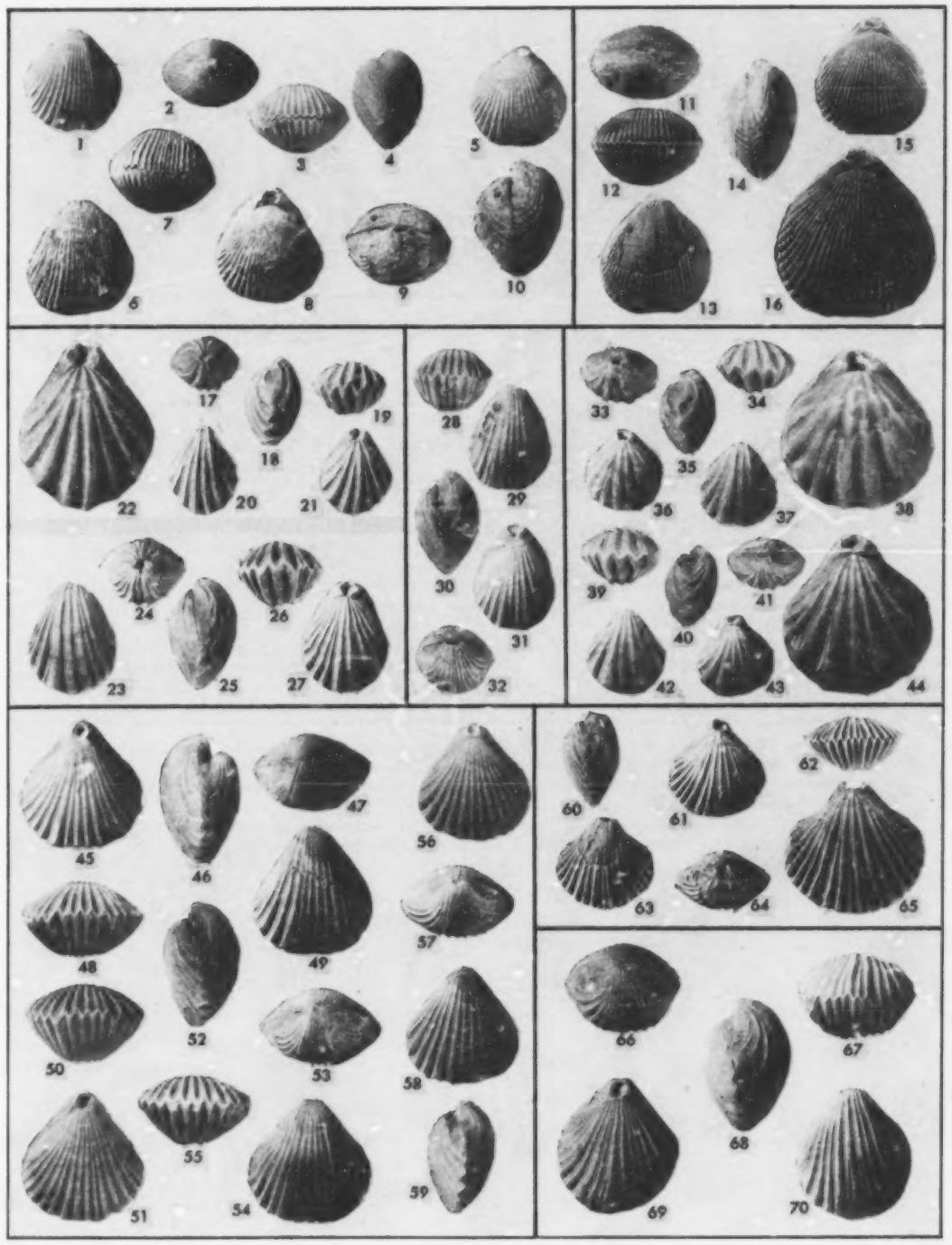
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PLATE 35

FIGURES 1–10.—*Sphriganaria cardioides* (Douvillé): 1–5, anterior, posterior, side, dorsal, and ventral views, ×1, of a typical specimen, hypotype, USNM 402735a; 6–10, posterior, anterior, side, ventral, and dorsal views, ×1, of a small hypotype, USNM 402735b. Locality: Lower Callovian, Gebel Enga Bash, Sinai Peninsula, Egypt.

FIGURES 11–31.—*Sphriganaria magharensis* (Farag), new combination: 11–15, posterior, side, anterior, dorsal, and ventral views, ×1, hypotype, USNM 380307. 16, dorsal view, ×1.5 of the preceding specimen; 17–21, dorsal, anterior, side, ventral, and posterior views, ×1, of hypotype, USNM 380308a; 22–26, dorsal, side, ventral, posterior, and anterior views, ×1, hypotype, USNM 380333a; 27–31, dorsal, posterior, anterior side, and ventral views, ×1, hypotype, USNM 380309. Localities: 11–16, S1001; 17–21, S1503; 22–26, S1501; 27–31, KK9-95–96.

FIGURES 32–37.—*Sphriganaria capax*, new species: 32–36, dorsal, ventral, side, anterior, and posterior views, ×1, holotype, USNM 380338a; 37, dorsal view, ×1, of a large paratype, USNM 380338b. Locality S1295.

FIGURES 38–43.—*Sphriganaria concentrica*, new species: 38–42, anterior, posterior, dorsal, side, and ventral views, ×1, holotype, USNM 380346; 43, dorsal view, ×2, of the holotype showing concentric lines. Locality KK7-96.

FIGURES 44–49, *Sphriganaria distans*, new species: 44–48, ventral, anterior, posterior, side, and dorsal views, ×1, holotype, USNM 380507; 49, dorsal view, ×1.5, of the holotype. Locality KK7-131.

FIGURES 50–54.—*Sphriganaria eximia*, new species: anterior, posterior, side, ventral, and dorsal views, ×1, holotype, USNM 380506. Locality S1162.

FIGURES 55–59.—*Eudesia cardium* (Valenciennes): ventral, anterior, side, posterior, and dorsal views of a large individual, ×1, hypotype, USNM 400919. Locality: Bathonian, Ranville, Calvados, France.

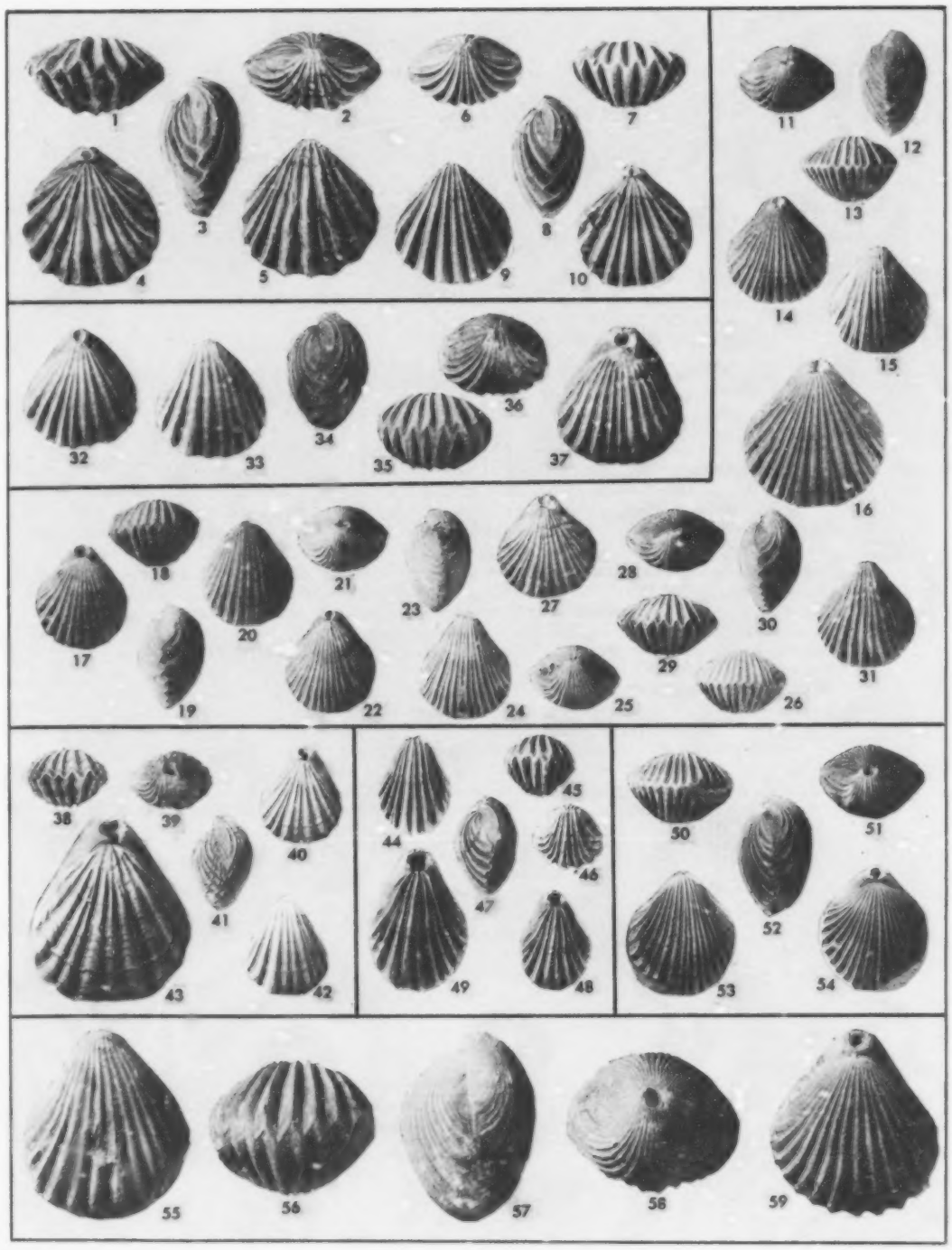
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PLATE 36

FIGURES 1–5.—*Sphriganaria nasuta*, new species: posterior, anterior, ventral, dorsal, and side views, ×1, holotype, USNM 380337. Locality S1501.

FIGURES 6–17.—*Sphriganaria parva*, new species: 6, dorsal view, ×1, paratype, USNM 380351a; 7–11, dorsal, anterior, ventral, side, and posterior views, ×2, of the preceding paratype; 12, dorsal view, ×1, holotype, USNM 380351b; 13–17, side, ventral, posterior, anterior, and dorsal views, ×2, of the holotype. Locality S1244.

FIGURES 18–22.—*Sphriganaria magnicostata*, new species: posterior, anterior, side, dorsal, and ventral views, ×1, holotype, USNM 380334a. Locality S1747.

FIGURES 23–27.—*Sphriganaria modesta*, new species: posterior, anterior, side, dorsal, and ventral views, ×1, holotype, USNM 380318a. Locality S1295.

FIGURES 28–32.—*Sphriganaria obesa*, new species: posterior, ventral, side, anterior, and dorsal views, ×1, holotype, USNM 380364. Locality KK9-30–40.

FIGURES 33–57.—*Xenorina ovata*, new species: 33, 34, side and dorsal views ×1, of a paratype, USNM 380368; 35, 36, interiors, ×2, showing thick hinge plate and cardinal process, paratypes USNM 380193g, f; 37–41, posterior, dorsal, side, ventral, and anterior views, ×1, holotype, USNM 380193a; 42–46, side, dorsal, anterior, posterior, and ventral views of a smaller paratype, ×1, USNM 380193b; 47, dorsal view, ×1, of a narrow paratype, USNM 380367. 48–51, ventral, anterior, posterior, and side, views, ×1, of a large paratype, USNM 380376; 52–56, anterior, side, posterior, dorsal, and ventral views, ×1, of a small paratype, USNM 380303a; 57, dorsal view, ×1.5, of the preceding paratype. Localities: 33, 34, S1235; 35–46, S1460; 47, S1010; 48–51, S1444; 52–57, S1478.

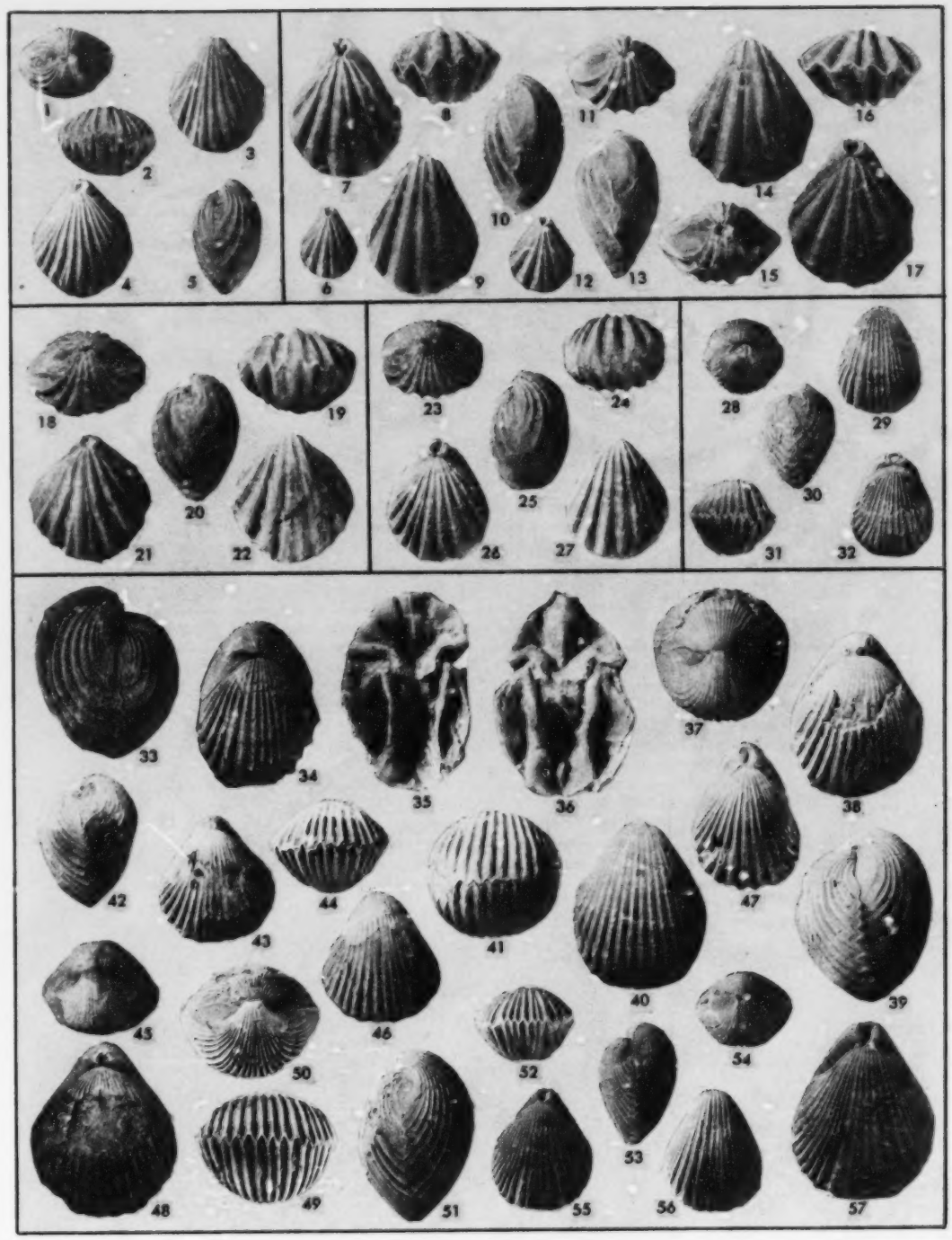
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PLATE 37

FIGURES 1–21.—*Calyptoria carinata*, new species: 1–5, dorsal, side, ventral, anterior, and posterior views, ×1, paratype, USNM 380326a; 6–10, ventral, anterior, dorsal, side, and posterior views, ×1, of a paratype with exceptionally carinate fold, USNM 380324e; 11, interior showing snarply pointed median septum ×1, paratype, USNM 380324-1; 12–16, anterior, dorsal, side, posterior, and ventral views, ×1, of the holotype USNM 380324a; 17–21, dorsal, posterior, anterior, side, and ventral views, ×1, paratype, USNM 380326b. Localities: 1–5, 17–21, S1034; 6–16, S1031.

FIGURES 22–31.—*Sphriganaria magharensis* (Farag), new combination: 22–26, dorsal, anterior, side, ventral, and posterior views, ×1, hypotype, USNM 380455a; 27–31, dorsal, anterior, posterior, side,, and ventral views, ×1, of a specimen larger than the preceding, hypotype, USNM 380455b. Locality KK8-3C-35.

FIGURES 32–36.—*Sphriganaria bramkampi*, new species: anterior, dorsal, side, posterior, and ventral views, ×1, paratype, USNM 380332a. Locality S1251.

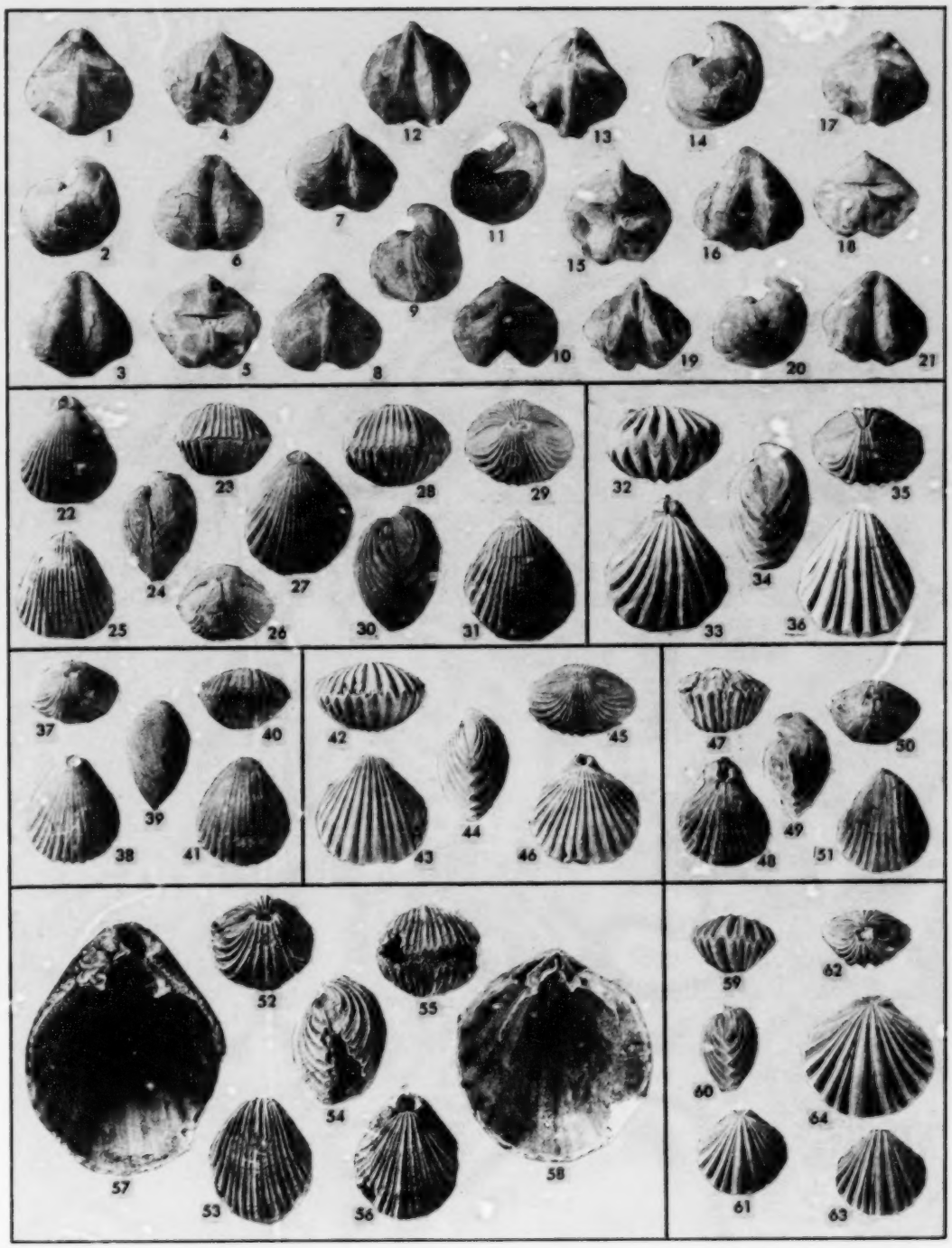
FIGURES 37–41.—*Sphriganaria perovalis*, new species: posterior, dorsal, side, anterior, and ventral views, ×1, holotype, USNM 380341. Locality KK8-23.

FIGURES 42–46.—*Sphriganaria subcircularis*, new species: anterior, ventral, side, posterior, and dorsal views, ×1, holotype, USNM 380315. Locality KK7-96.

FIGURES 47–51.—*Sphriganaria* species 1: anterior, dorsal, side, posterior, and ventral views, ×1, of a specimen with long, incurved beak, USNM 380505. Locality S1619.

FIGURES 52–58.—*Sphriganaria varicostata*, new species: 52–56, posterior, ventral, side, anterior, and dorsal views, ×1, holotype, USNM 380345; 57, 58, ventral and dorsal interiors, ×2, of the holotype showing teeth, and folded hinge plate with part of descending branch of loop. Locality S1170.

FIGURES 59–64.—*Sphriganaria rara*, new species: 59–63, anterior, side, dorsal, posterior, and ventral views, ×1, holotype, USNM 380339; 64, dorsal view, ×1.5 of the holotype. Locality KK7-10.5.



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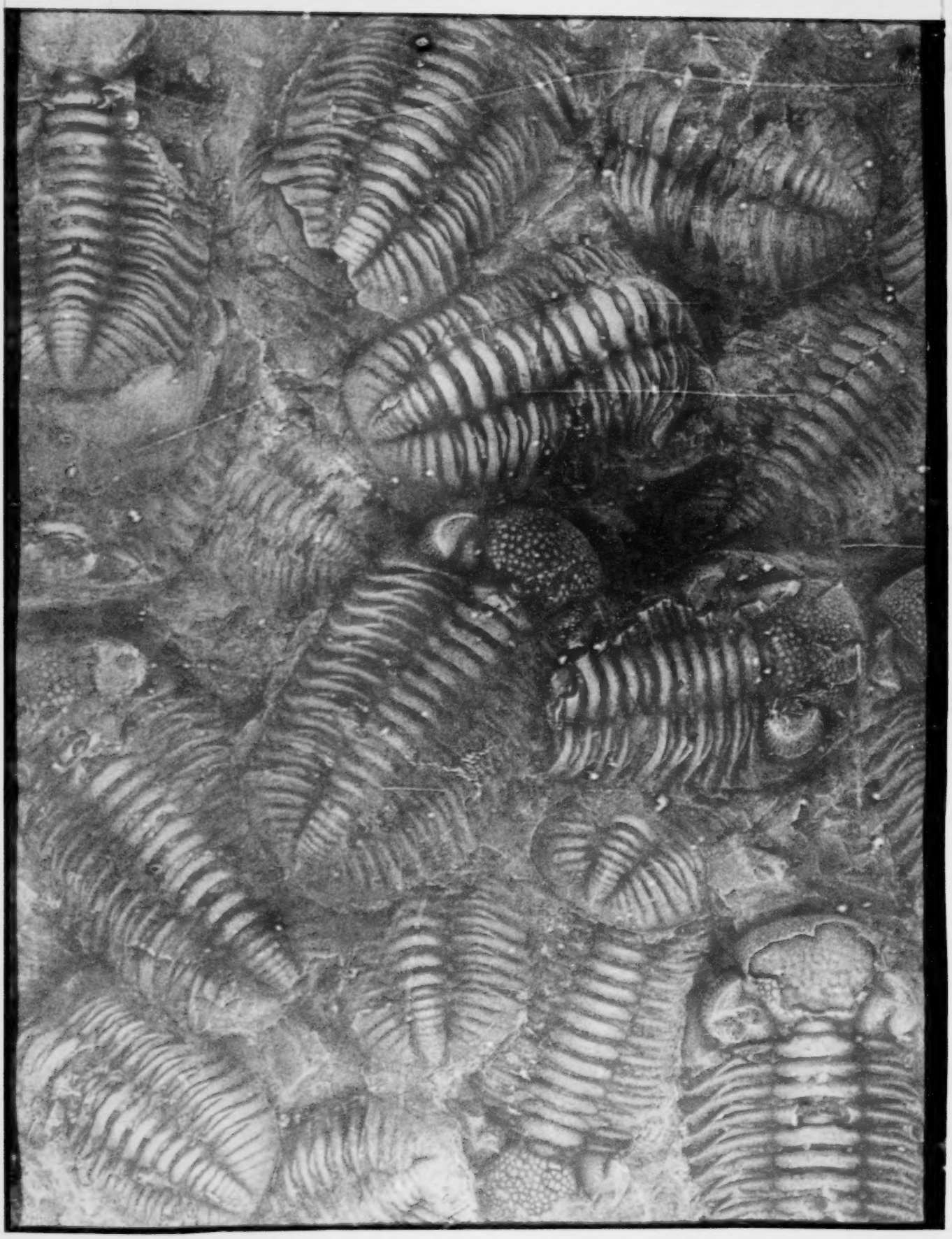
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